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# NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1975

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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16. ABSTRACT

This report presents national and regional trends in air quality through 1975 for total suspended particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide and oxidants. The change in the number of people exposed to air quality levels above the National Ambient Air Quality Standards is emphasized. Changes in air quality levels are discussed for two selected areas: the New York-New Jersey-Connecticut Air Quality Control Region, accounting for 17 million people, and the Los Angeles Basin, accounting for 8 million people. Both areas show considerable improvement in reducing adverse pollution levels. The trend analyses in this report are based on the data collected through the extensive monitoring activities conducted by Federal, State and local air pollution control agencies. Nationwide emissions for the period 1970-1975 are also presented.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
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November 1976

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# NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1975

## 1. INTRODUCTION AND OVERVIEW

### 1.1 GENERAL OVERVIEW

Considerable progress has been made in achieving compliance with the National Ambient Air Quality Standards (NAAQS) for total suspended particulate, sulfur dioxide, carbon monoxide, and oxidants. In contrast, however, trends for nitrogen dioxide are mixed. The progress is measured by comparing the ambient air pollution levels with appropriate primary and secondary NAAQS for each of the pollutants. Primary standards protect the public health, and secondary standards protect the public welfare as measured by effects of pollution on vegetation, materials, and visibility. The standards are further categorized for long- or short-term exposure. Long-term standards specify an annual mean that may not be exceeded; short-term standards specify upper limit values for 1-, 3-, 8-, or 24-hour averages that may not be exceeded more than once per year.

Pollutant measurements are compared with standards in this report. Data for analysis were obtained from the U.S. Environmental Protection Agency's National Aerometric Data Bank (NADB). These data are gathered primarily from state and local air pollution control agencies through their monitoring activities.

This is the fifth report on air pollution trends issued by the Environmental Protection Agency.[1-4] Unlike past reports, this report treats only trends in air quality (section 3) and emissions (section 4). The air quality appendices contained in past reports[1-4] identified the Air Quality Control Region, the site location and number, and also contained air quality summary statistics by pollutant. This type of information will be published in a separate report.

In this report the change in the number of people exposed to air quality levels above the National Ambient Air Quality Standards (NAAQS) is emphasized. Changes in population exposure to air quality levels are discussed for two selected areas: the New York-New Jersey-Connecticut Air Connecticut Air Quality Control Region, accounting for 17 million people, and the Los Angeles Air Basin, accounting for 8 million people. In the New York-New Jersey-Connecticut Study, emphasis was focused on the change in population exposed to total suspended particulate levels above the NAAQS. Changes in the population exposed to ozone and nitrogen dioxide levels above the NAAQS were stressed in the Los Angeles study.

The major findings of the investigations are as follows:

1. Based on data collected at approximately 1800 monitoring sites, the estimated number of people in the nation exposed to total suspended particulate levels in excess of the annual primary standard decreased from 73 million in 1970 to 49 million in 1974. This improvement indicates that 24 million fewer people were exposed to levels above the standard.

2. As a result of switching to cleaner fuels and implementing particulate control measures, approximately 7 million fewer people in the New York-New Jersey-Connecticut Air Quality Control Region were exposed to total suspended particulate concentrations in excess of the primary health standard of 75 micrograms per cubic meter ($\mu g/m^3$) in 1974 than in 1971. The improvement affects the total population, as well as the school-age and elderly populations, which are the least mobile and most susceptible.

3. The population exposure study in the Los Angeles Air Basin showed a considerable reduction in the percent of days when the 1-hour oxidant standard was violated. People in the Basin were exposed to a concentration above the standard on an average of 176 days per year in 1965 and 1966. By 1973 and 1974 they were exposed an average of 105 days per year. People in the Basin were exposed to a concentration of nitrogen dioxide ($NO_2$) above the 1-hour California welfare standard of 470 $\mu g/m^3$ on an average of 25 days per year in 1965 and 1966, 27 days per year in 1969 and 1970, and 18 days per year in 1973 and 1974. These data show improvement in the past 5 years.

4. The most recent sulfur dioxide ($SO_2$) ambient air data from 545 monitoring sites show that conentrations in urban areas have decreased by an average of 30 percent since 1970. The improvement occurred rapidly in the 1970-1973 period and then leveled off as many areas came into compliance. Major point sources located outside of urban areas, such as non-ferrous smelters, pose the greatest threat to achievement of the NAAQS for sulfur dioxide at the present time.

5. Improvement was noted at approximately 80 percent of the sites measuring carbon monoxide (CO) throughout the nation. The rate of improvement was more pronounced in California, where the CO emission standards are more stringent.

6. Data from sites monitoring oxidant showed considerable improvement in the Los Angeles Basin, the San Francisco Bay Area, and the San Diego Air Basin.

7. A preliminary analysis of short-term trends (1973-1975) suggests a decline in summer oxidant/ozone violations in the eastern part of the United States (eight sites decreasing and three sites increasing) and a general increase in metropolitan Denver (five sites increasing). There are too few sites with sufficient historical data in the remainder of the nation to characterize trends.

8. Nitrogen dioxide level trends vary geographically. A significant decline occurred in the Los Angeles Basin Between 1971-1975, but in the San Francisco Bay Area, as many sites increased as decreased. Recent declines have occurred in three cities in New Jersey and in Denver, Colorado. No significant trend for nitrogen dioxide was found in the two other cities examined, Chicago, Illinois, and Portland, Oregon.

## 1.2 REFERENCES FOR SECTION 1


1. *The National Air Monitoring Program: Air Quality and Emissions Trends* - Annual Report, Volumes 1 and 2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-73-001 a and b. July 1973.

2. *Monitoring and Air Quality Trends Reports, 1972.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-73-004. December 1973.

3. *Monitoring and Air Quality Trends Report, 1973.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-74-007. October 1974.

4. *Monitoring and Air Quality Trends Report, 1974.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-76-001. February 1976.

# 2. FEWER PEOPLE EXPOSED TO ADVERSE AIR POLLUTION IN TWO LARGEST METROPOLITAN AREAS

The number of people exposed to certain levels of air pollution has changed dramatically during the 1970's. In the past, trends in air quality have been reported[1-4] in terms of means, percentiles, and/or maximum pollutant concentrations, all of which are statistically derived from air monitoring data. Trends in these pollutant concentration statistics are reasonable measures of progress; however, they do not directly indicate improvement in terms of the number of people being exposed to levels above the primary NAAQS. Because the purpose of primary standards (health-related) is the protection of public health, studies have been undertaken in two geographical areas[5,6] to measure the impact of emission control plans on population groups exposed to air pollution levels above the NAAQS. Both air quality data and population data are factored into this "population exposure" approach.

Population exposure analyses were conducted for the New York-New Jersey-Connecticut Air Quality Control Region (AQCR) and the Los Angeles Air Basin. These two areas were selected because they are among the nation's largest metropolitan areas and also have extensive air-monitoring networks. The New York-New Jersey-Connecticut AQCR accounts for 17 million people and has a total of 103 suspended particulate monitors, which have provided sufficient historical data to examine trends. The Los Angeles Basin contains a population of 8 million people and has extensive oxidant and nitrogen dioxide monitoring networks. The analysis in New York, therefore, focuses on the change in population exposure to total suspended particulate levels between 1971 and 1974, and the Los Angeles analysis examines the change in population exposed to oxidant and nitrogen dioxide levels from 1965 through 1974. Both analyses required the merging of local population and air quality data to compute several measures of pollutant exposure. In order to accomplish this task, 1970 population data for both areas were "gridded" into a network of population receptor points; each point represented a subset of the areas' total population. A spatial interpolation procedure[5] was then employed to estimate the air quality at each population receptor point. This procedure yielded estimates of population exposure for the total population by place of residence. The progress in reducing both the number of people exposed and the frequency of exposure to pollutant levels above the NAAQS is discussed in the following sections.

## 2.1 MAJOR DECREASE IN POPULATION EXPOSED TO HIGH PARTICULATE LEVELS IN THE NEW YORK-NEW JERSEY-CONNECTICUT AIR QUALITY CONTROL REGION

The change in number of people exposed to total suspended particulate matter in the New York-New Jersey-Connecticut AQCR was examined for the period from 1971 through 1974. Overall, significant progress has been made in reducing population exposure to annual average TSP levels. As a result of switching to cleaner fuels and implementing particulate control measures, typical annual concentration levels were reduced 25 percent. This improvement is shown to have resulted in 71 percent fewer people living in areas exposed to concentration in excess of the annual primary health standard of 75 $\mu g/m^3$. In addition, progress has been made in reducing the number of repeated exposures to high daily concentrations.

### 2.1.1 Methodology

Air quality data produced by the TSP monitoring network in the Tri-State Region were examined together with demographic statistics to determine the change in resident populations exposed to ambient air pollution of various levels. In 1970 about 17 million people were living in the study area. Population density within the study area is depicted in Figure 2-1. The most densely populated areas are found in the urban core consisting of most of New York City and parts of eastern New Jersey, where TSP concentrations are also generally the highest.

Figure 2-2 presents the location of the 103 TSP monitors that provided the air quality data for this analysis. Two years, 1971 and 1974, were selected to demonstrate the change in population exposure over time. Each of these monitoring sites produced a valid* year of data in 1971 and 1974.

*A valid year of data is based on a minimum of five 24-hour average values per calendar quarter.

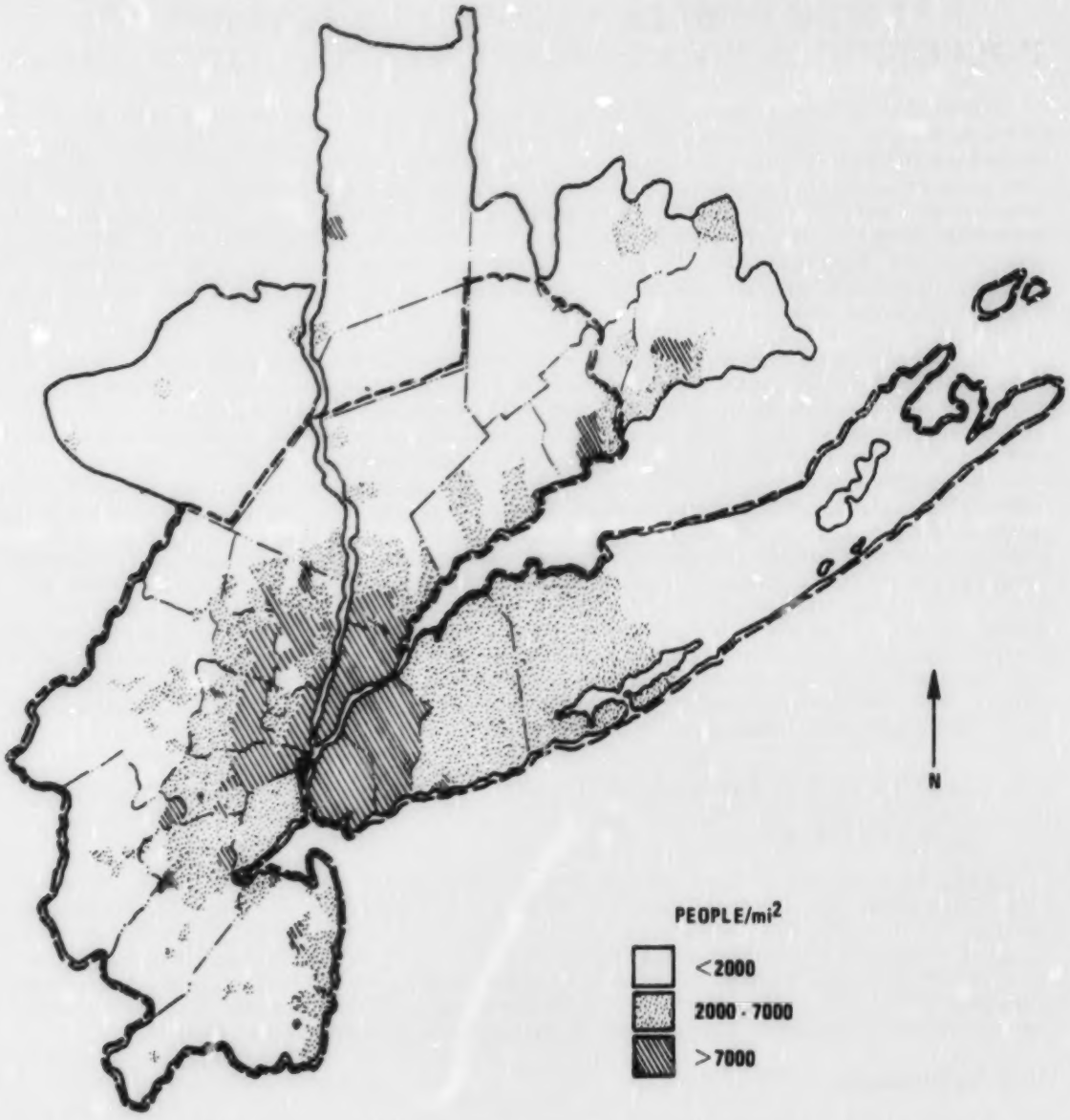


*Figure 2-1. Population pattern in 1970 for New York - New Jersey - Connecticut Air Quality Control Region.*

A network of 215 receptor points was used to interface the air quality and population data. Each receptor point represented a subset of the total population, as well as a subset of the less mobile but susceptible school-age and elderly populations. This network, displayed in Figure 2-3, provides complete area coverage, and more detail is afforded densely populated areas. The TSP air quality of each grid point of the network was estimated from the actual monitoring data by spatial interpolation. The estimates of population and air quality were then used to characterize the region.

### 2.1.2 TSP Air Quality Patterns

Spatial air quality patterns are described in terms of annual concentrations and the frequency that daily concentrations exceed the daily welfare standard (150$\mu g / m^3$). The secondary standard was used because it

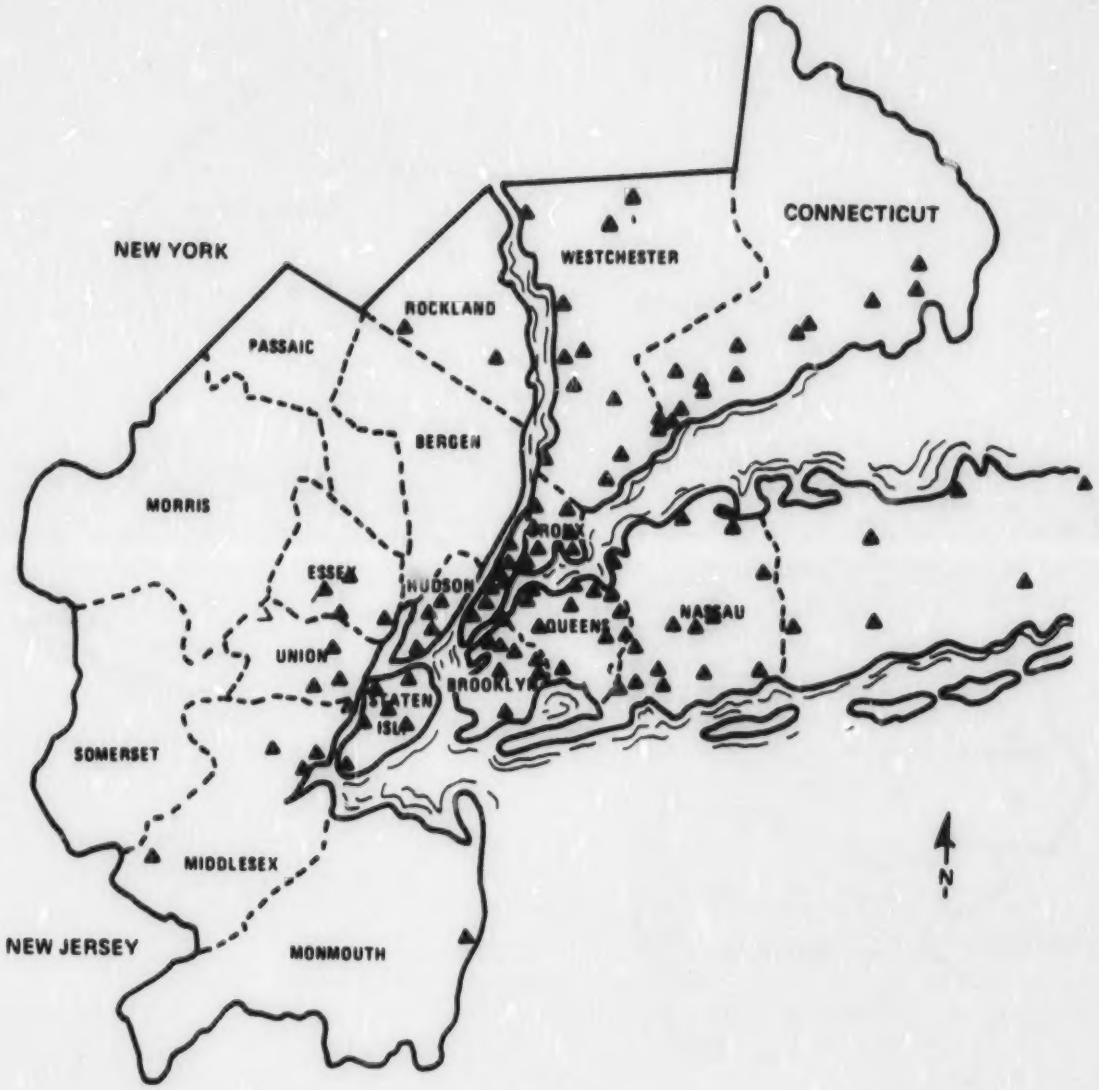


*Figure 2-2. Location of 103 total suspended particulate monitors in study area.*

was violated more frequently than the primary standard and was, therefore, more illustrative of change in TSP levels over time. Trends in air quality patterns are demonstrated by comparison of isopleth maps in 1971 and 1974.

Isopleths of average TSP during 1971 are shown in Figure 2-4. The highest concentration levels are found in the central portion of the region. Nineteen percent of the total land area in this region was exposed to annual average concentrations greater than the primary NAAQS. The corresponding spatial distribution during 1974 is shown in Figure 2-5. As can be seen, there was an overall reduction in TSP levels throughout the region between 1971 and 1974. The land area exposed to concentrations in excess of the annual primary standard has been reduced to less than 4 percent of the Air Quality Control Region.

Daily exposure patterns are described in terms of isopleth maps that contour areas of the region that exceed 150 $\mu g/m^3$ for a given percent of the days. Figures 2-6 and 2-7 show these contours for 1971 and 1974. In 1971 almost one-third of the total area exceeded the standard 5 percent of the time, but by 1974 this area had been reduced 50 percent.

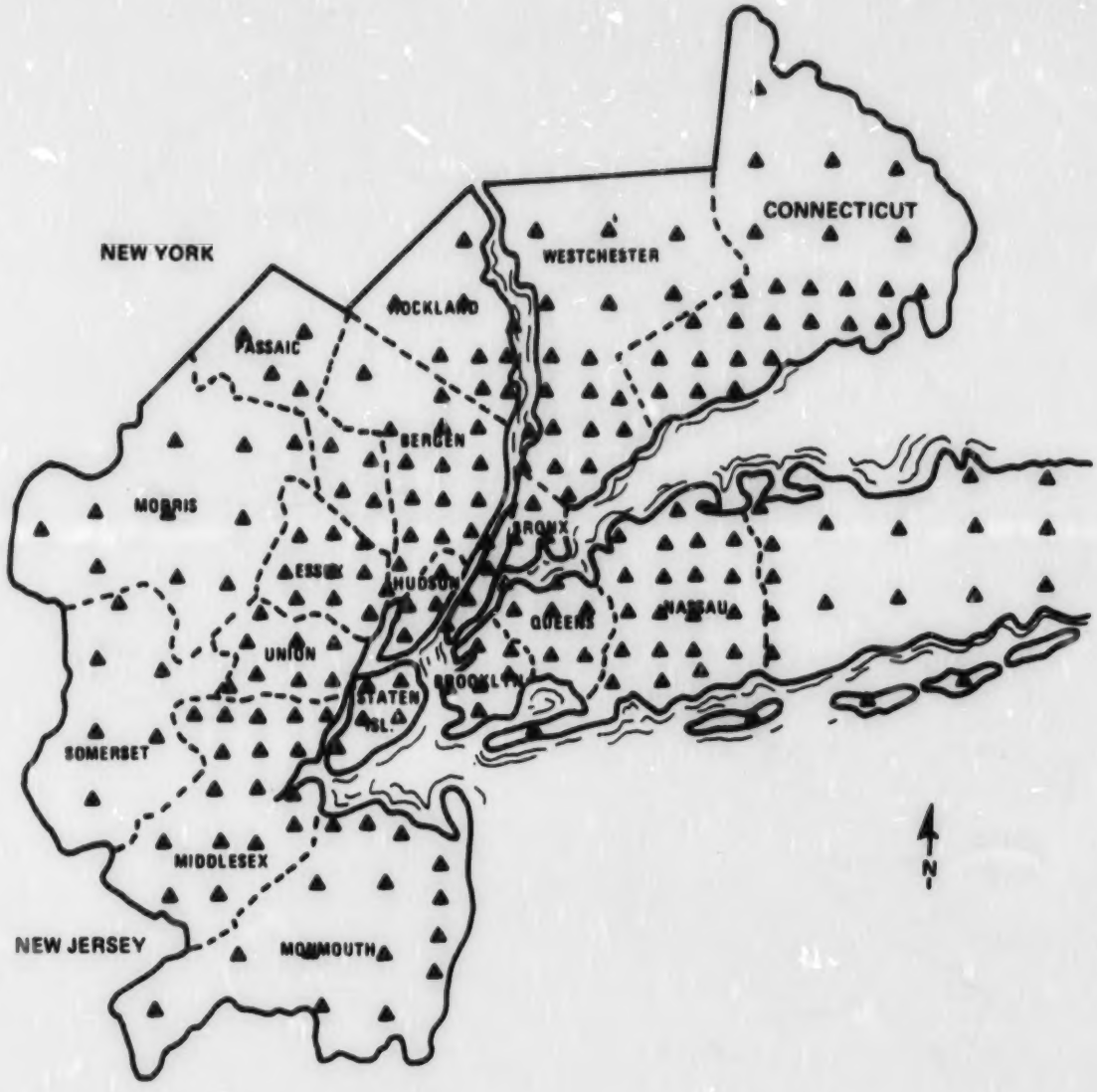


*Figure 2-3. Standarized network of receptor points in study area.*

### 2.1.3 Changes in Population Exposed

Trends in population exposure were evaluated in terms of (1) annual averages and (2) the frequency of occurrence of daily TSP concentrations in excess of 150 $\mu g / m^3$. These concentration statistics were used to determine the cumulative number of people associated with a particular annual average concentration or frequency of occurrence. These population exposure distributions were then compared for 1971 and 1974.

The population exposure distribution for 1971 and 1974 for annual averages is shown in Figure 2-8. For example, 58 percent of the total population in 1971 was residing in areas wherein annual TSP levels were exceeding the primary annual TSP standard of 75 $\mu g / m^3$. By contrast, in 1974, TSP levels had decreased to the point that only 17 percent of the population was exposed to annual concentrations above the primary annual NAAQS.

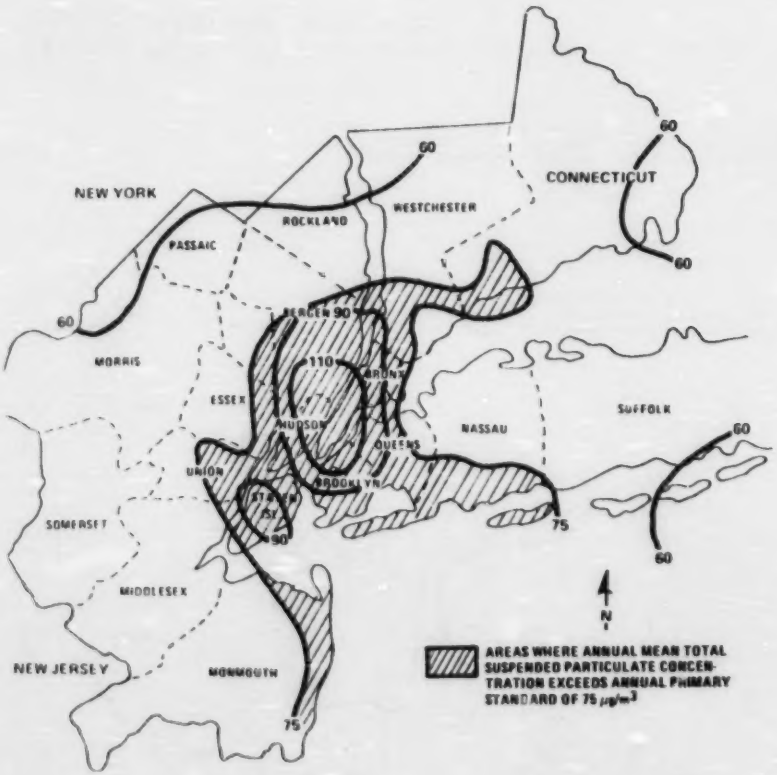


*Figure 2-4. Isopleths of annual geometric mean concentrations of total suspended particulate in 1971.*

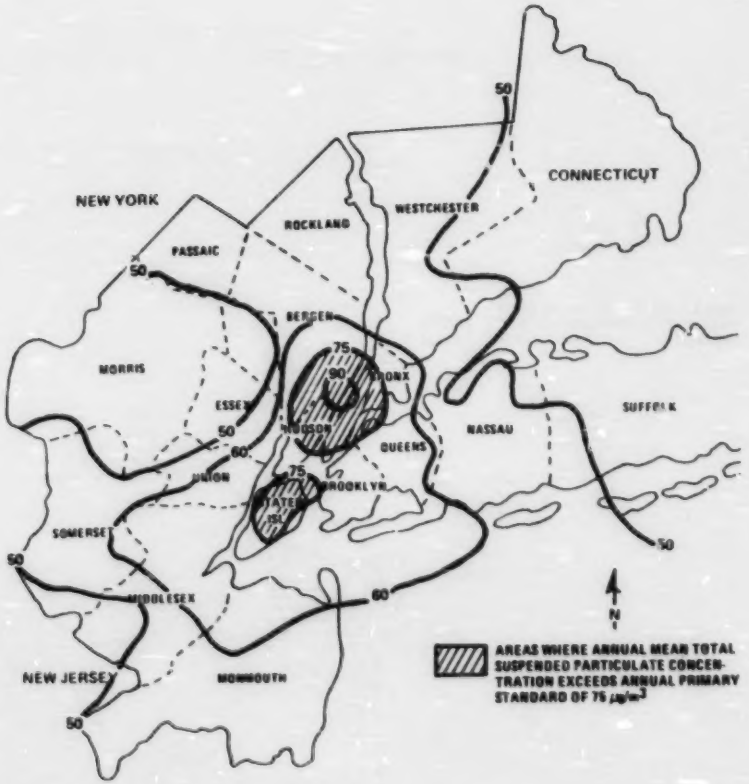


*Figure 2-5. Isopleths of annual geometric mean concentrations of total suspended particulate in 1974.*

NOTE: ISOPLETH MAPS ARE BASED ON SPATIAL INTERPOLATION FROM DATA MEASURED AT 103 MONITORING SITES. LOCAL TSP MAY VARY BECAUSE OF METEOROLOGY, TOPOGRAPHY, AND EMISSIONS.

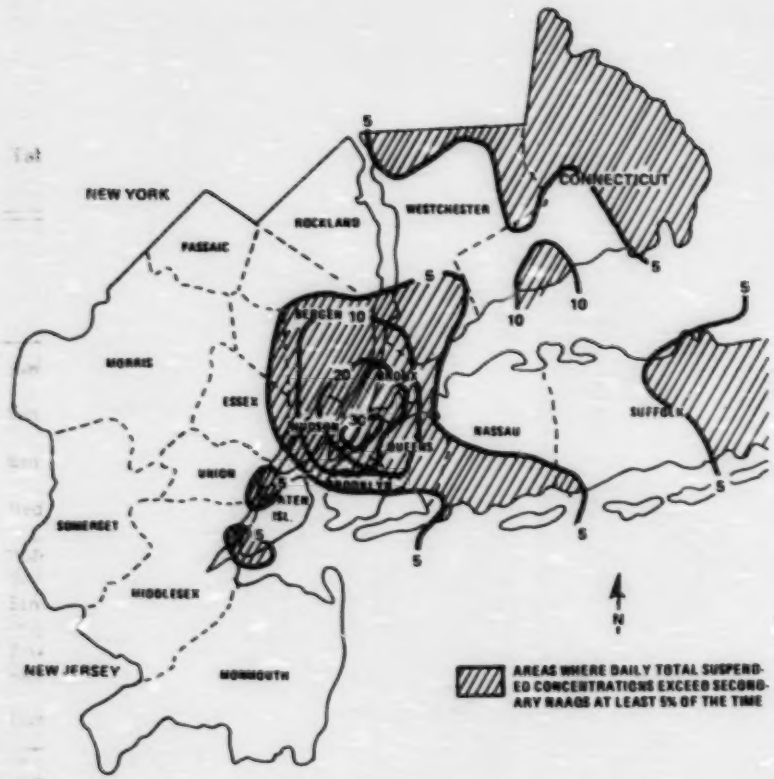


*Figure 2-6. Percent of daily total suspended particulate concentrations exceeding NAAQS (150μg/m³) in 1971.*

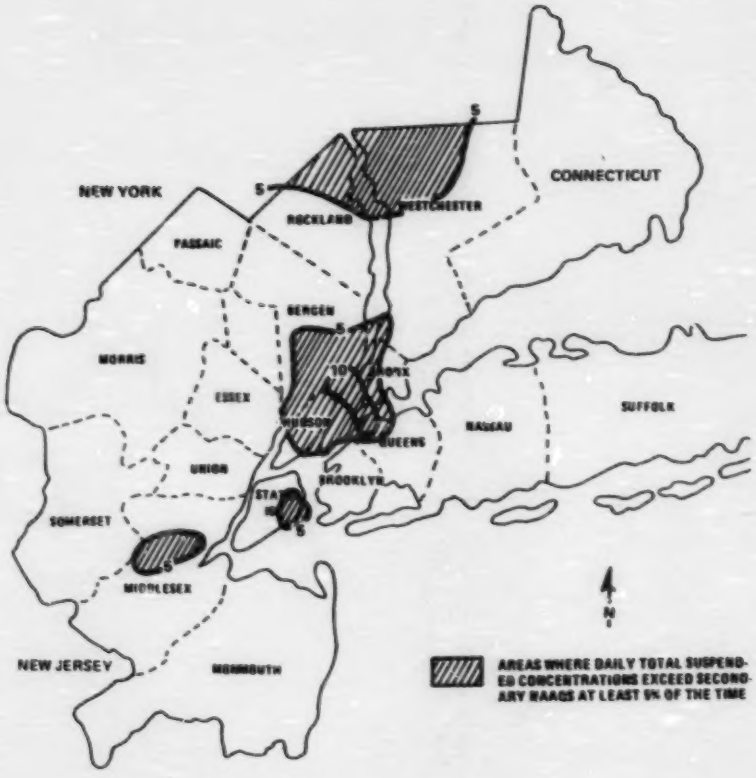


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*Figure 2-7. Percent of daily total suspended particulate concentrations exceeding NAAQS (150μg/m³) in 1974.*

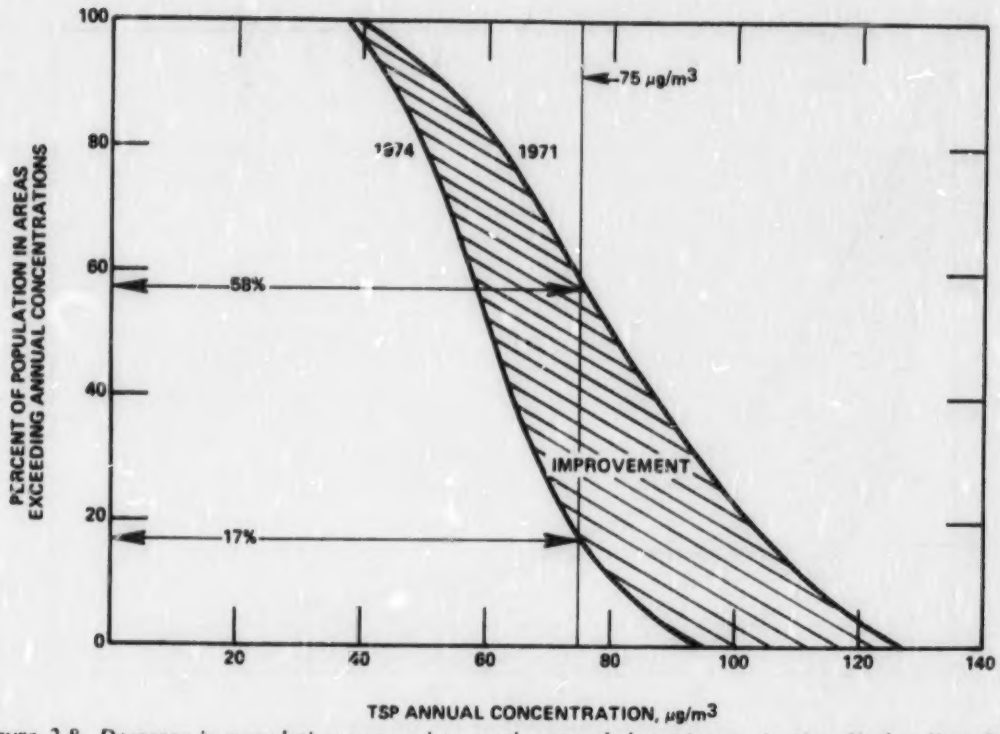


*Figure 2-8. Decrease in population exposed to total suspended particulate in New York - New Jersey - Connecticut Air Quality Control Region from 1971 to 1974.*

Table 2-1 shows the population exposure for two subpopulations, the elderly and school-age children. A slightly higher proportion of the elderly population is living in areas of higher annual TSP levels, but the overall rates of progress are similar for the total population, the elderly, and school-age children.

The population exposure distributions for daily averages are shown in Figure 2-9 for 1971 and 1974. In 1971, 58 percent of the population lived in areas exposed to 150 $\mu g/m^3$ more often than 5 percent of the days. In 1974, however, only 15 percent of the population was exposed that often to this level. Table 2-2 shows the population exposure distribution for various exposure frequencies in terms of the percent improvement from 1971 to 1974. As would be expected, fewer people are affected by the higher frequencies of exposure. Also, the improvement in terms of the percent reduction in population exposure becomes larger for the higher exposure frequencies.

**Table 2-1. NUMBER OF PEOPLE LIVING IN AREAS EXCEEDING NATIONAL AMBIENT AIR QUALITY STANDARD FOR TOTAL SUSPENDED PARTICULATE IN STUDY AREA IN 1971 AND 1974[a]**

| Population category | Total population | Percent of category population | | Percent reduction in population exposed to levels above annual primary NAAQS for TSP |
|---|---|---|---|---|
| | | 1971 | 1974 | |
| Total population | 17,000,000 | 58 | 17 | 71 |
| School age | 3,900,000 | 53 | 14 | 74 |
| Elderly | 1,800,000 | 64 | 20 | 69 |

[a]Annual NAAQS for total suspended particulate is 75 micrograms per cubic meter.

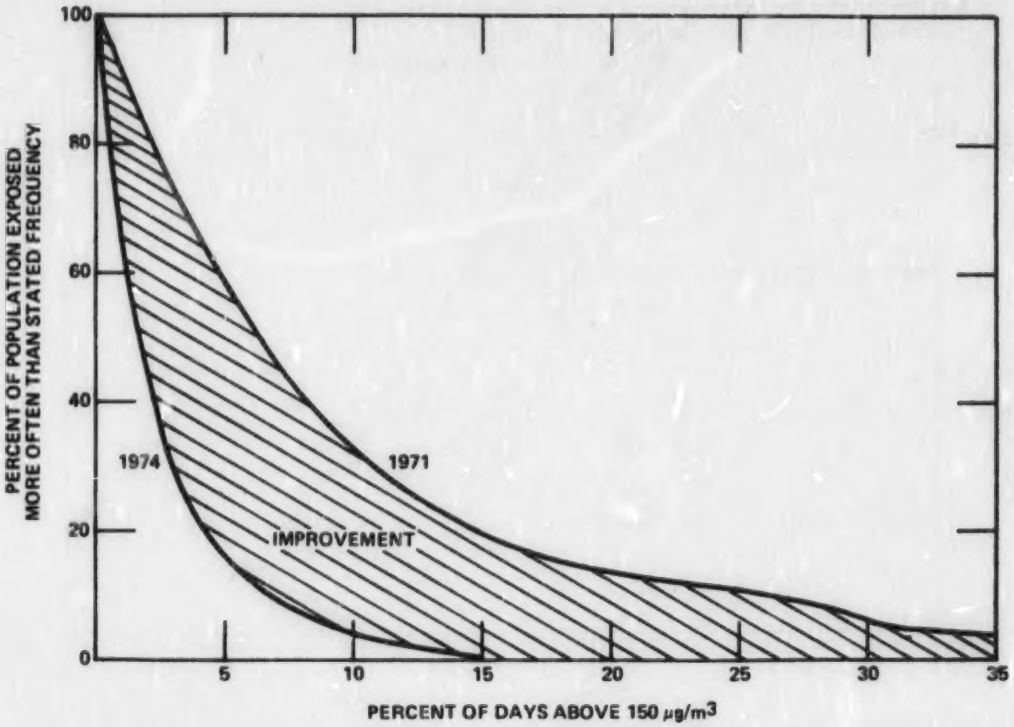


*Figure 2.9. Population exposed daily to total suspended particulate above 150 μg/m³ in New York - New Jersey - Connecticut Air Quality Control Region.*

**Table 2-2. PERCENT OF POPULATION LIVING IN AREAS EXCEEDING 24-HOUR NATIONAL AMBIENT AIR QUALITY STANDARD FOR TOTAL SUSPENDED PARTICULATE**

| Exposure frequency | Percent of total population | | Percent improvement |
|---|---|---|---|
| | 1971 | 1974 | |
| At least 1 day | 86 | 72 | 17 |
| ≥ 5% of days | 57 | 15 | 74 |
| ≥ 10% of days | 32 | 4 | 86 |
| ≥ 15% of days | 19 | 1 | 95 |

### 2.1.4 Conclusion

The discussion above shows that TSP air quality improvements can be described in terms of a number of separate but related indicators. Four of these trend indicators are: (1) changes in annual averages, (2) changes in the percent of days exceeding 150 $\mu g/m^3$, (3) changes in the percent of people exposed to the annual standard, and (4) changes in the percent of people living where 5 percent or more days exceed 150 $\mu g/m^3$. Table 2-3 is a summary of the improvement in TSP by each of the four types of indicators.

**Table 2-3. COMPARISON OF TRENDS IN TOTAL SUSPENDED PARTICULATE AIR QUALITY MEASURES IN NEW YORK-NEW JERSEY-CONNECTICUT AIR QUALITY CONTROL REGION**

| Air quality measure | 1971 | 1974 | Percent change |
|---|---|---|---|
| Mean of annual averages | 79 $\mu g/m^3$ | 61 $\mu g/m^3$ | 23 |
| Percent days exceeding daily NAAQS (150 $\mu g/m^3$) | 7.7% | 3.0% | 61 |
| Percent of people living where annual averages exceed 75 $\mu g/m^3$ | 58% | 17% | 71 |
| Percent of people living where 5% or more of days exceed 150 $\mu g/m^3$ | 57% | 15% | 74 |

The improvement is largely due to the success of emission control plans. Examination of meteorological data suggests that with the exception of precipitation, 1971 appears meteorologically similar to 1974. In 1971, there was approximately 20 percent more precipitation than in 1974. Since precipitation tends to remove particles from the air, it might be expected that the additional precipitation would lower TSP levels slightly compared to 1974, if emissions were equal. Thus, the improvement in the air quality indicators shown in Table 2-3 can logically be attributed to the success of the emission control plans.

## 2.2 MAJOR REDUCTION IN PERCENT OF TIME METROPOLITAN LOS ANGELES POPULATION IS EXPOSED TO PHOTOCHEMICAL POLLUTION

An analysis similar to that for the New York area was made to examine the change in population exposure to oxidants and nitrogen dioxide in the Los Angeles Air Basin. Air quality data collected from 1965 through 1974 were grouped into 2-year intervals to preserve historical continuity among the trend sites.[6] The analysis showed a considerable reduction in the percent of days the 1-hour primary health standard for oxidant was violated. People in the Basin were exposed to a concentration above the standard on an average of 176 days per year in 1965 and 1966, 144 days per year in 1969 and 1970, and 105 days per year in 1973 and 1974. Analysis of nitrogen dioxide data also showed some improvement; people were exposed to a concentration above the 1-hour California welfare standard of 470 $\mu g/m^3$ on an average of 25 days per year in 1965 and 1966, 27 days per year in 1969 and 1970, and 18 days per year in 1973 and 1974. Although the California standard is related to visibility, it served as a convenient reference point to evaluate population exposure to hourly concentrations of nitrogen dioxide. In addition, progress has been made in the duration of exposure, particularly in the case of oxidants.

### 2.2.1 Methodology

Air quality data collected at ten air monitoring stations measuring oxidants and eight measuring nitrogen dioxide were examined together with population statistics prepared by the Southern California Association of Governments (SCAG) and with the 1970 census data. A population of 7.9 million was associated with the oxidant monitoring data, and the nitrogen dioxide monitoring network was judged to represent 6.5 million people. Figure 2-10 depicts the spatial variation of the population density over the study area. Figure 2-11 presents the location of the ten monitoring sites that provided the air quality data for this analysis.

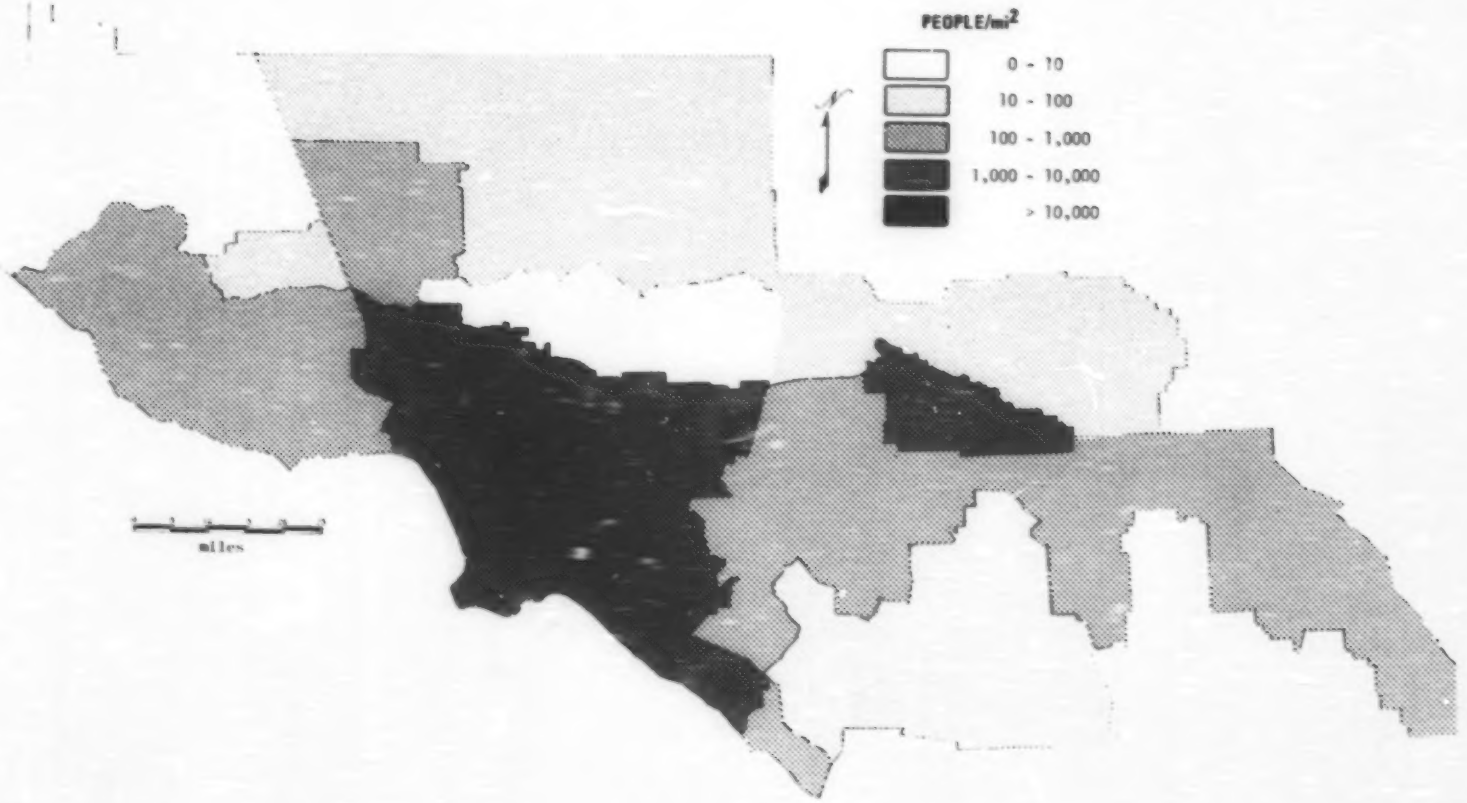


*Figure 2-10. Population density of Los Angeles Air Basin in 1970.*

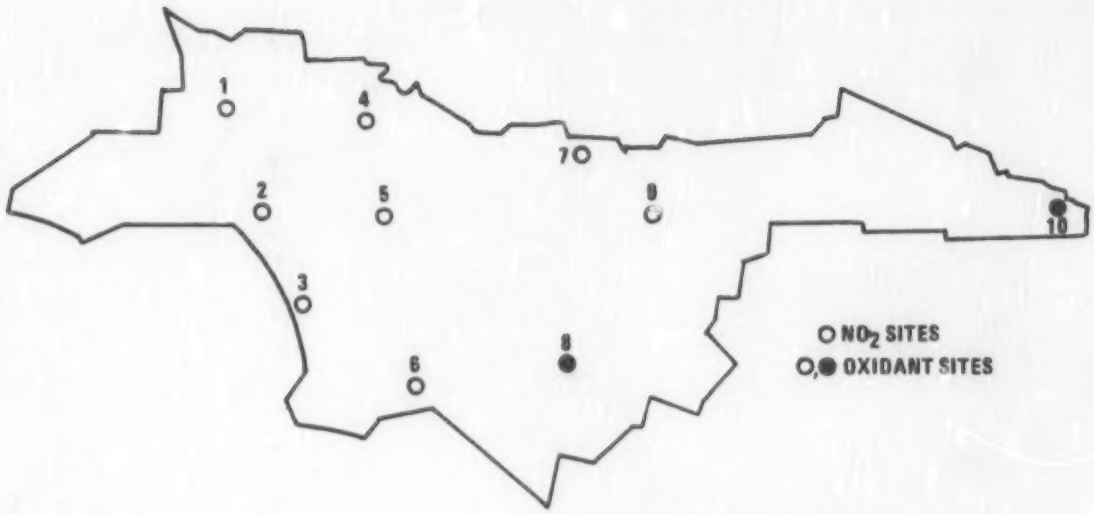


*Figure 2-11. Locations of nitrogen dioxide and oxidant trend sites in Los Angeles Air Basin.*

The air quality and population data were interfaced by using a standardized network of 57 receptor points for the oxidant analysis and 45 receptor points for the nitrogen dioxide analysis (Figure 2-12). The standardized network provides complete area coverage, but more detail is given to areas of high population density. Each standard network point thus represents a local population as well as its air quality. The oxidant and nitrogen dioxide air quality of each grid point of the standardized network was estimated from the actual monitoring data by spatial interpolation. The estimates of population and air quality were then used to characterize the region.

### 2.2.2 Changes in Population Exposed to Oxidants

Daily exposure patterns are displayed on isopleth maps to indicate areas of the region that exceed the 1-hour oxidant standard of 160 $\mu g/m^3$ for a given percent of the days (Figure 2-13). In 1965 and 1966 more than

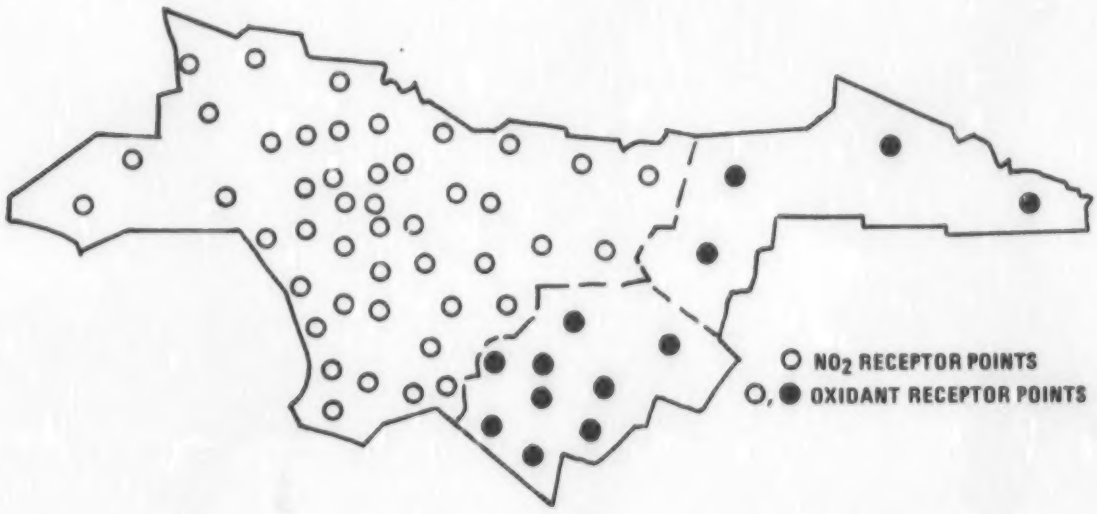


*Figure 2-12. Standard demographic network for trend analysis in Los Angeles Air Basin.*

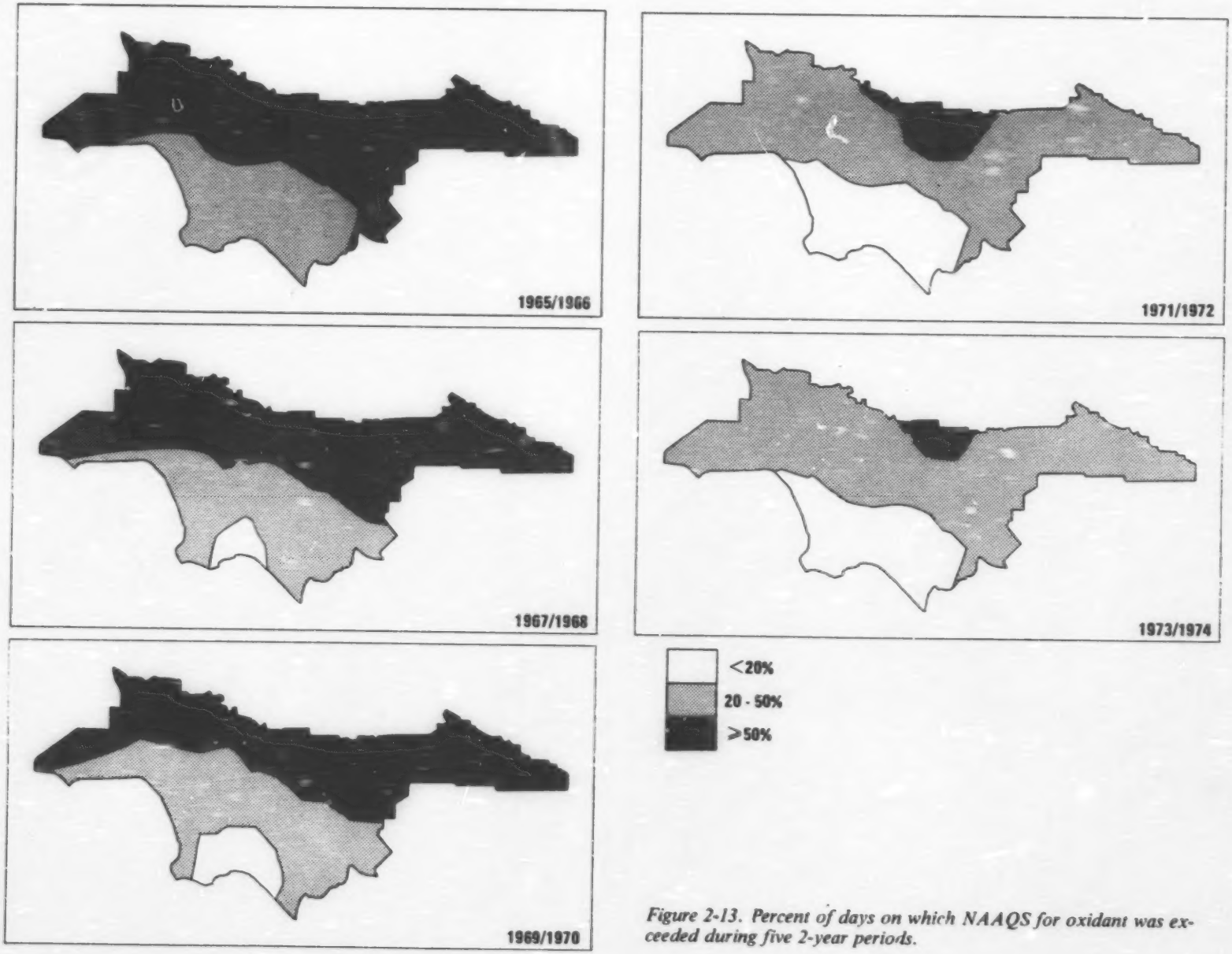


*Figure 2-13. Percent of days on which NAAQS for oxidant was exceeded during five 2-year periods.*

half of the Basin violated the standard more than 50 percent of the days and the rest of the region at least 20 percent of the days. In 1973 and 1974 the area where the standard was violated more than 50 percent of the days decreased to a small area around Azusa. The area where the standard was violated less frequently than 20 percent of the days appeared in the southern half of the region.

For the days on which the oxidant primary standard was violated, the average number of hours of violation per day was examined for the 10-year period (Figure 2-14). In 1965 and 1966 the average duration was longer than 6 hours per day in the inland areas and longer than 3 hours per day in the coastal areas. By the end of the 10-year period of interest, the average duration in a majority of the inland areas was shorter than 6 hours per day, but still longer than 3 hours per day in some of the coastal areas.

Figure 2-15 depicts the improvements in population exposure to oxidant levels from 1965 through 1974. Each vertical bar with different hatch marks indicates the percentages of the population exposed to a concentration above the standard at various percentages of days. For example, in 1965 and 1966, 53 percent of the population was exposed to a concentration above the standard on at least 50 percent of the days. In 1973 and 1974 the percentage of the population with the same exposure dropped to less than 5 percent. The second group of veritical bars represents the percent of the population exceeding a level twice as high as the standard. The third group is for three times the oxidant standard.

The region-wide trends in population exposure to oxidant are summarized in Table 2-4. People in the study region were exposed to a concentration above the standard on an average of 176 days per year during 1965 and 1966, 144 days per year in 1969 and 1970, and 105 days per year in 1973 and 1974. The average duration of such exposure also decreased from 5.1 hours per day in 1965 and 1966 to 4.6 hours per day in 1969 and 1970 and to 4.3 hours per day in 1973 and 1974. The trends are similar for values greater than twice th standard.

The improvement seen in oxidant levels can be explained by meteorological conditions and emission trends. The overall 10-year decline in oxidants reflects the steady reduction in reactive hydrocarbon emissions, but some of the declines during the period can be associated with meteorological cycles. The high oxidant levels during the period 1965 through 1970 were associated with an unusually high number of days with poor dispersion. The meteorological cycle reversed itself during the period 1971 through 1974 when more days had good dispersion conditions.

Table 2-4 shows that the 1971 and 1972 annual average of the daily hourly duration is the lowest of the 10-year period. These 2 years had the fewest hourly excursions of the primary 1-hour standard and twice the standard during their third quarters. The third quarter is the most important quarter in the oxidant season since the highest oxidant concentrations and the most frequent violations of the standard occur during that time of the year. A reduction in the 1971 and 1972 third-quarter concentrations and hourly violations of the standard resulted in the lowest annual average of the daily hourly duration. During the third quarters of 1971 and 1972, more days had a higher-than-average wind speed than during third quarters of the other 8 years.

A more detailed discussion of the effects of meteorology and emissions on oxidant trends in the Los Angeles Basin is presented in section 3.4.2

### 2.2.3 Changes in Population Exposed to Nitrogen Dioxide

Isopleth maps for nitrogen dioxide annual mean concentrations are shown in Figure 2-16. Over much of the study region the annual average primary NAAQS of 100 $\mu g/m^3$ was violated throughout the entire 10-year period. The air quality has improved recently, however. From 1967 through 1972 concentrations greater than 130 $\mu g/m^3$ occurred in the majority of the heavily populated areas, but in 1973 and 1974 such levels were confined to the San Fernando Valley.

Figure 2-17 depicts the percentages of the population exposed to selected annual average levels of nitrogen dioxide. For example, the percentage of the population exposed to 130 $\mu g/m^3$ or higher annual mean

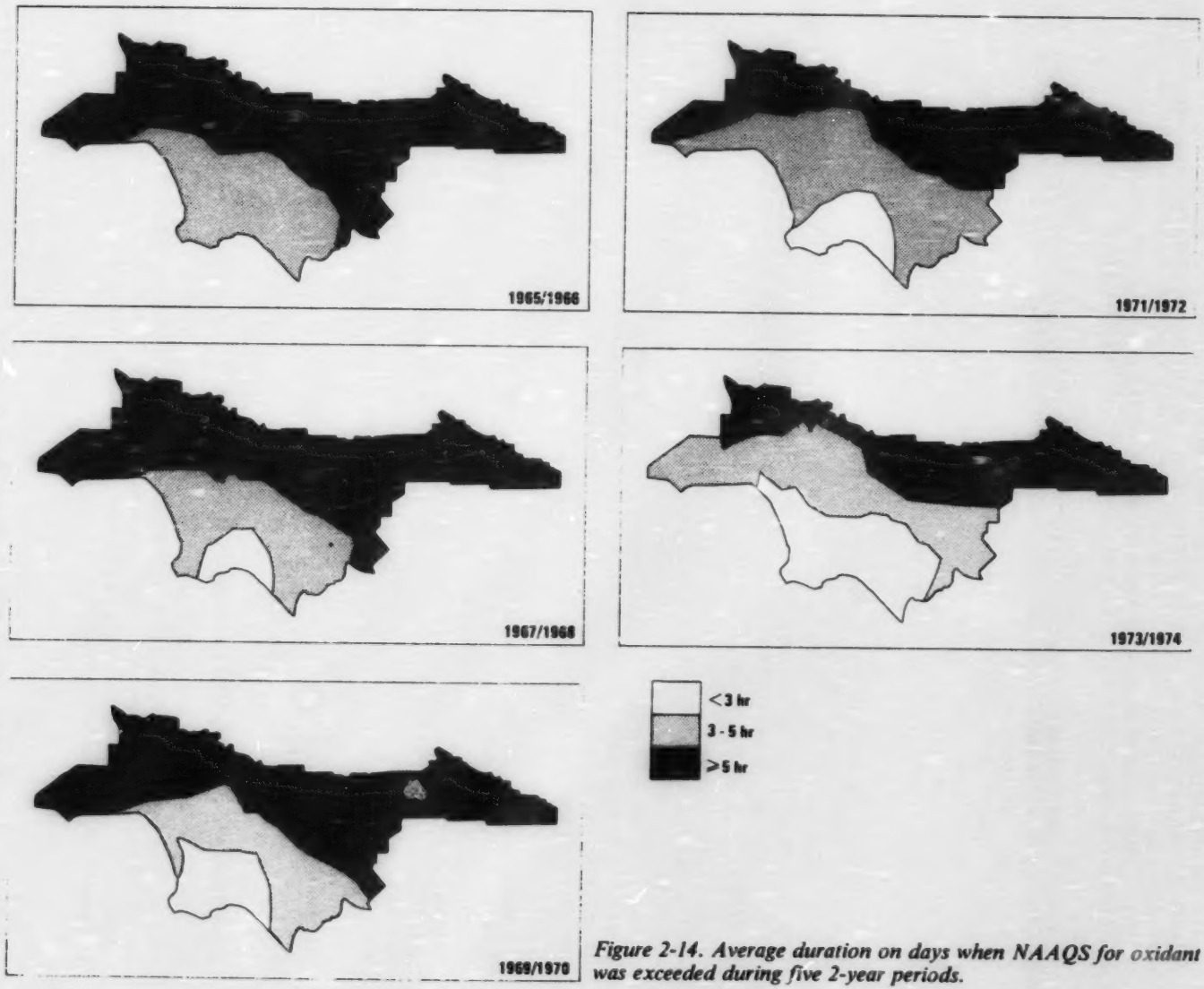


*Figure 2-14. Average duration on days when NAAQS for oxidant was exceeded during five 2-year periods.*

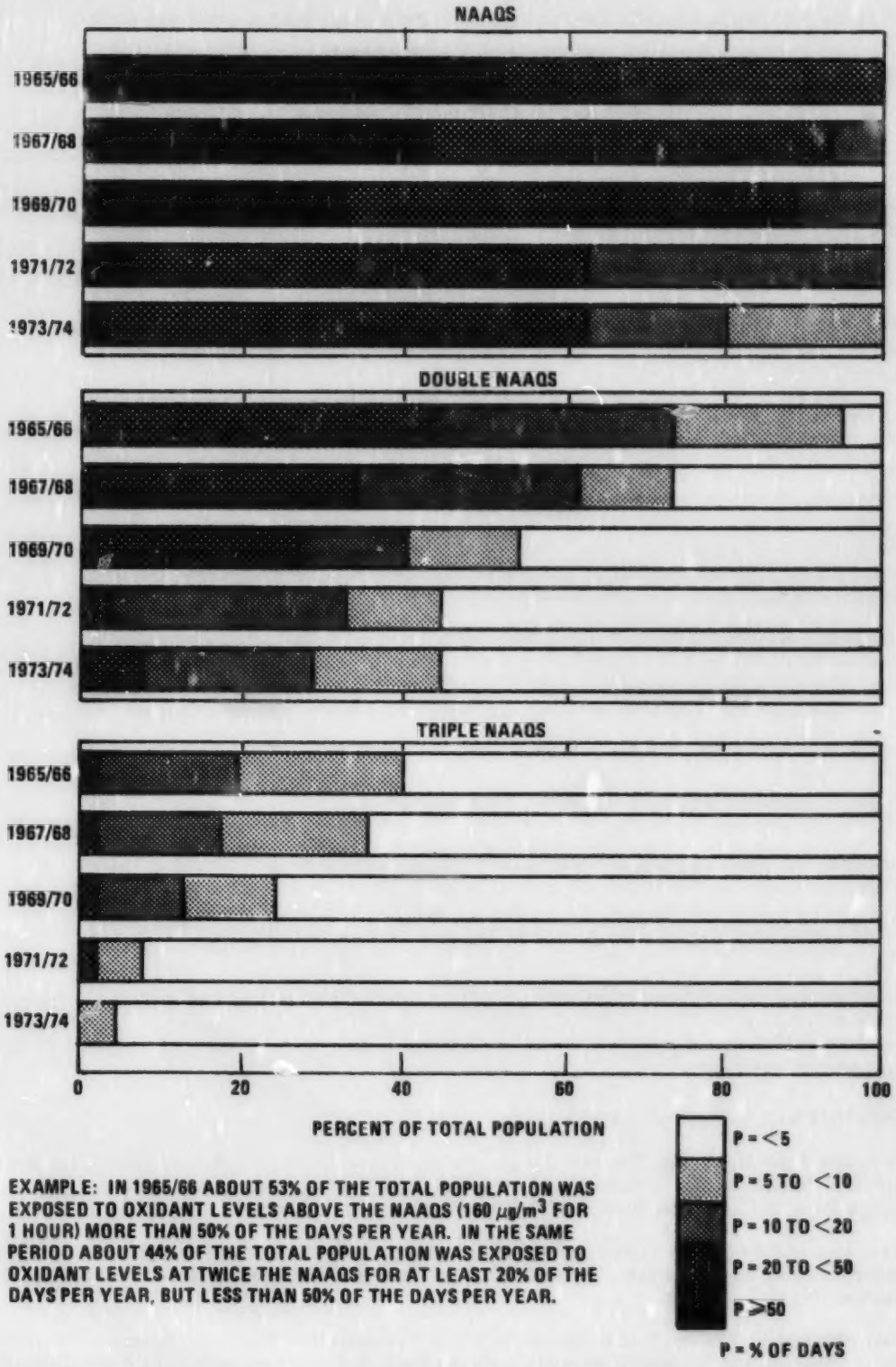


*Figure 2-15. Changes in population exposure to oxidant during five 2-year periods.*

Table 2-4. VIOLATIONS OF NAAQS FOR OXIDANT FROM 1965 TO 1975 IN LOS ANGELES AIR BASIN

| Index | 1965 and 1966 | 1967 and 1968 | 1969 and 1970 | 1971 and 1972 | 1973 and 1974 |
|---|---|---|---|---|---|
| Avg No. of days per year exceeding 160 $\mu g/m^3$ (8pphm) | 176 | 162 | 144 | 109 | 105 |
| Avg daily duration,[a] hr | 5.1 | 4.8 | 4.6 | 3.8 | 4.3 |
| Avg No. of days per year exceeding 320 $\mu g/m^3$ (16 pphm) | 70 | 59 | 45 | 26 | 26 |
| Avg daily duration,[b] hr | 3.1 | 3.1 | 2.8 | 2.1 | 2.9 |

[a]The average daily duration is the average number of hours per day above the oxidant NAAQS.

[b]The average daily duration is the average number of hours per day the oxidant level was twice the NAAQS.

concentration changed from 19 percent in 1965 and 1966 to 70 percent in 1969 and 1970, and back to 33 percent in 1973 and 1974. In contrast, virtually everyone was exposed to annual average nitrogen dioxide levels above the primary standard of 100 $\mu g/m^3$ between 1969 and 1974.

The isopleth maps of the percent of days the 1-hour California "welfare" standard of 470 $\mu g/m^3$ was violated are shown in Figure 2-18. The area exceeding the standard more frequently than 6 percent of the days was approximately matched with the area of the City of Los Angeles in 1965 and 1966, extended to almost the entire study region from 1967 through 1972, and was confined to the San Fernando Valley in 1973 and 1974.

The isopleth maps of the average hourly duration for days that the California 1-hour standard was exceeded are shown in Figure 2-19. The area with an average duration longer than 3 hours per day was confined to the north-central part of the San Fernando Valley in 1965 and 1966, extended to the majority of the study region from 1967 through 1972 and shrank to the Los Angeles downtown area in 1973 and 1974.

The region-wide trends in population exposure to nitrogen dioxide are summarized in Table 2-5. People in the study region were exposed to a concentration above the 1-hour California standard of 470 $\mu g/m^3$ on an average of 25 days per year in 1965 and 1966, 27 days per year in 1969 and 1970, and 18 days per year in 1973 and 1974. The average duration of such exposure changed from 2.6 hours per day in 1965 and 1966 to 3.0 hours per day in 1969 and 1970 and to 2.5 hours per day in 1973 and 1974.

The increasing (1965–1970) and decreasing (1971–1974) trends displayed in the population exposure statistics correspond to trends in oxides of nitrogen emissions. Emissions increased by 275 tons per day between 1966 and 1970 and are only now decreasing because of the emission standards for nitrogen dioxide for 1971 and later-model cars.[7]

## 2.3 REFERENCES FOR SECTION 2


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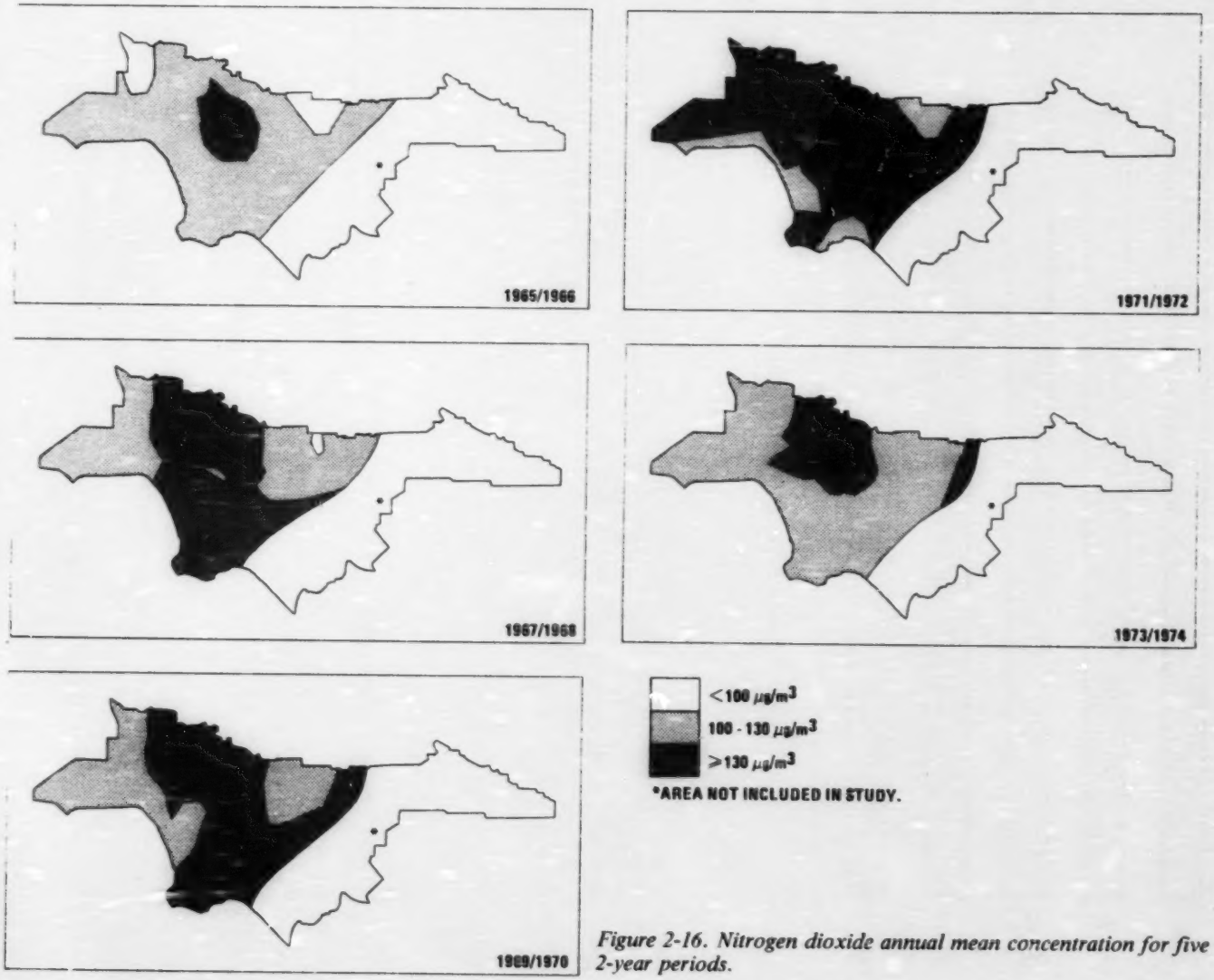


*Figure 2-16. Nitrogen dioxide annual mean concentration for five 2-year periods.*

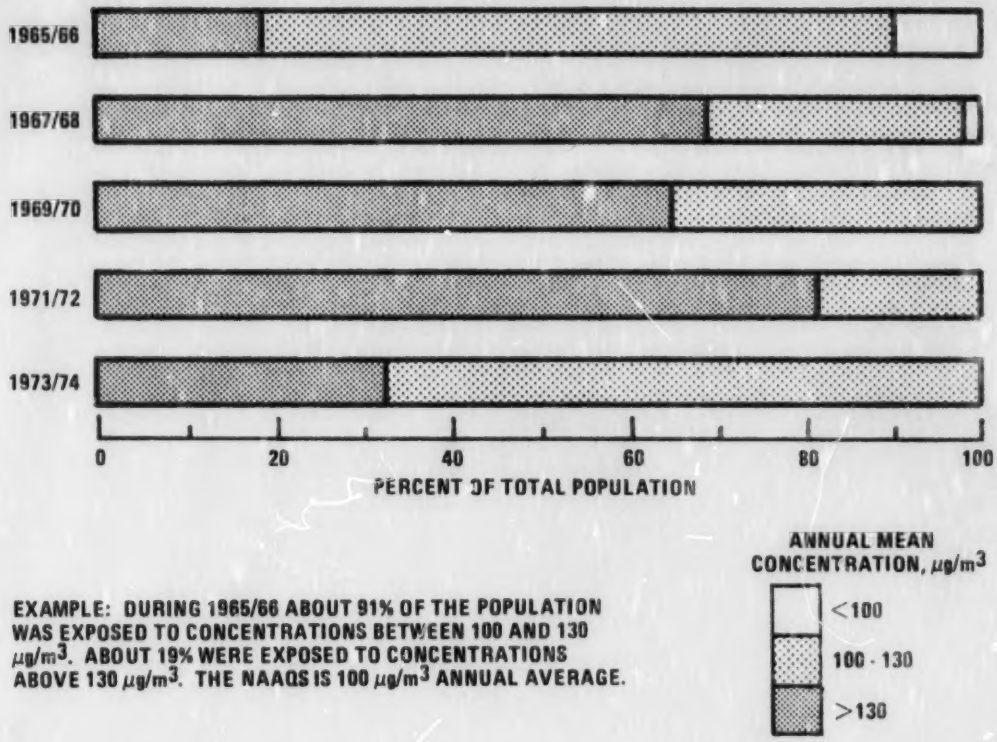


*Figure 2-17. Changes in total population exposed to nitrogen dioxide during five 2-year periods.*

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6. Horie, Yuji and A. Chaplin. *Analysis of Population Exposure to Oxidants and Nitrogen Dioxide in the Los Angeles Basin.* Technology Service Corporation, Santa Monica, California. Prepared for the Monitoring and Data Analysis Division, U.S. Environmental Protection Agency. August 5, 1976.

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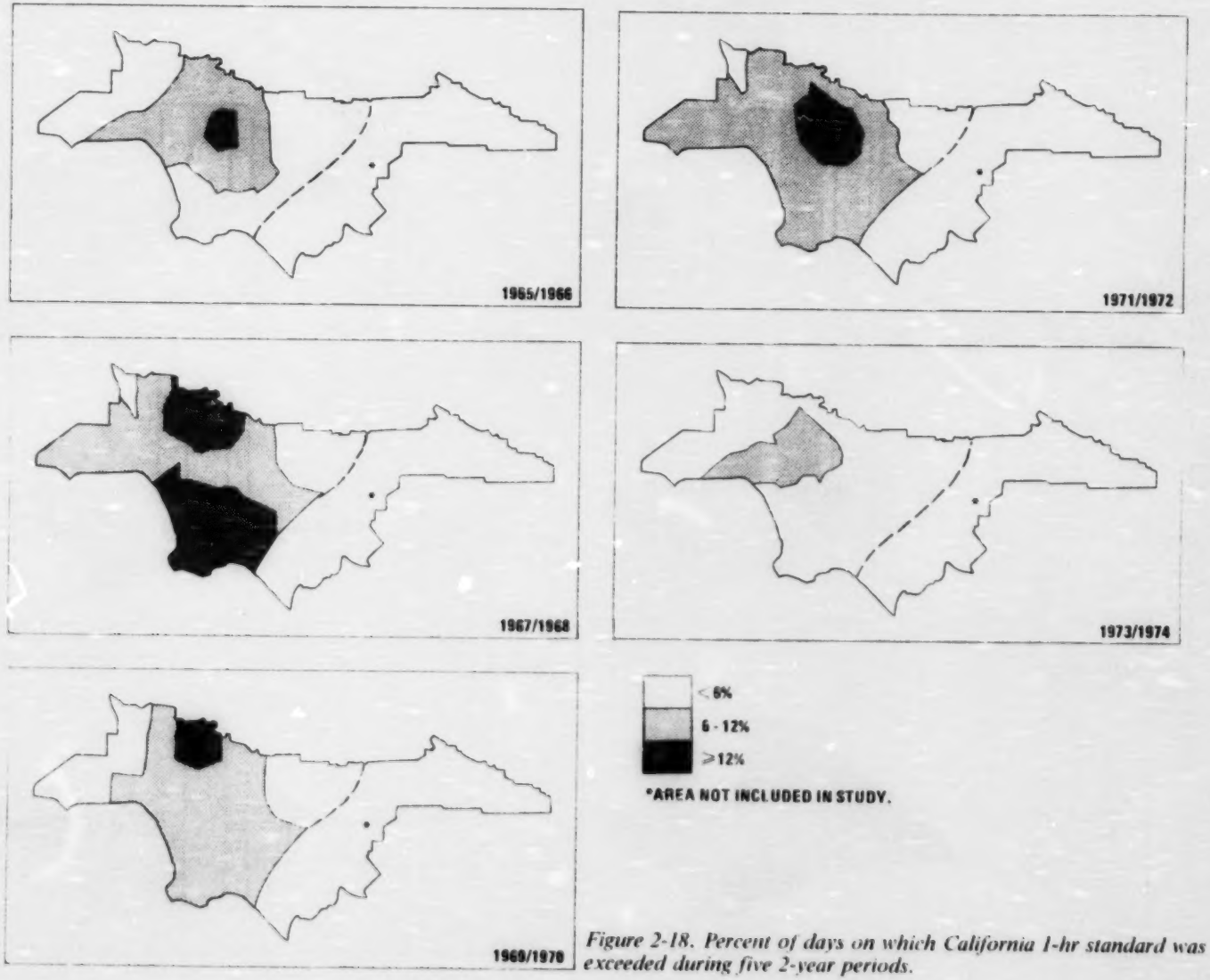


*Figure 2-18. Percent of days on which California 1-hr standard was exceeded during five 2-year periods.*

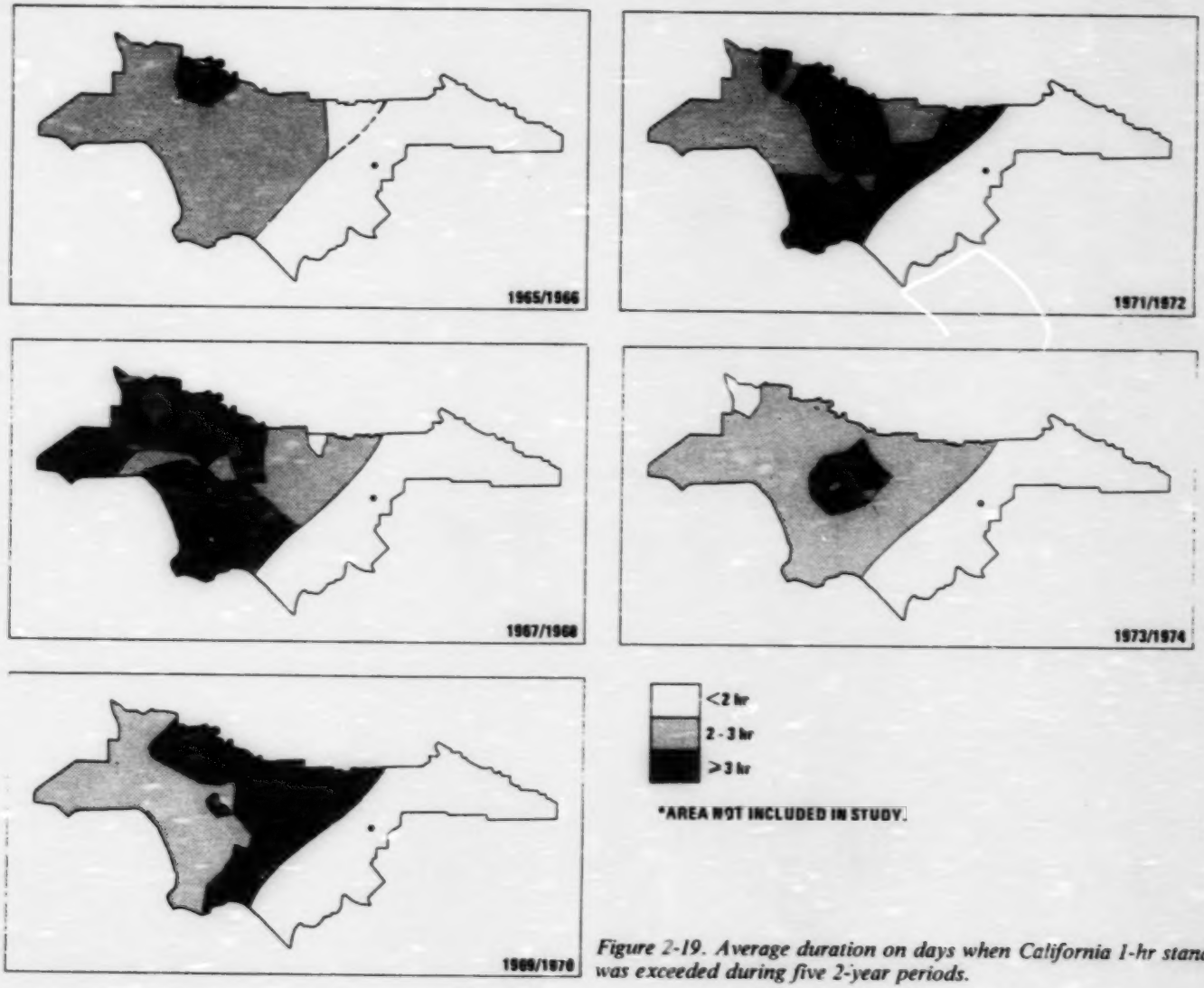


*Figure 2-19. Average duration on days when California 1-hr standard was exceeded during five 2-year periods.*

**Table 2-5. TREND IN VIOLATIONS OF CALIFORNIA 1-HOUR STANDARD FOR NITROGEN DIOXIDE AND AVERAGE DURATION[a,b]**

| Index | 1965/66 | 1967/68 | 1969/70 | 1971/72 | 1973/74 |
|---|---|---|---|---|---|
| Avg No. days per year with nitrogen dioxide level above 470 $\mu g/m^3$ | 25 | 40 | 27 | 33 | 18 |
| Avg duration, hr | 2.6 | 3.3 | 3.0 | 3.0 | 2.5 |

[a] 1-hour California standard for nitrogen dioxide of 470 $\mu g/m^3$ or 25 pphm.
[b] The average daily duration is the number of hours per day above the 1-hour nitrogen dioxide California standard.

# 3. NATIONAL AND REGIONAL TRENDS IN CRITERIA POLLUTANTS

The "criteria" pollutants are total suspended particulates, sulfur dioxide, oxidants, carbon monoxide, and nitrogen dioxide. The pollutant trends are discussed below on a national and on a regional basis. Obviously, there are many ways of looking at trends in air quality. The evaluation herein is a discussion of trends with respect to the National Ambient Air Quality Standards since the passage of the Clean Air Act of 1970.

## 3.1 TRENDS IN TOTAL SUSPENDED PARTICULATE

The general improvement in ambient air quality with respect to total suspended particulate discussed in previous reports[1-4] is continuing. Trends since 1971 indicate a general improvement of 4 percent per year based upon data from approximately 1800 sites. There have been some geographical differences with Northeast and Great Lakes areas improving at even higher rates. Trends in some of the Western states have been fairly stable, probably due to fugitive (wind blown) dust and to some extent due to secondary particulates caused by photochemical reactions in areas such as Los Angeles and San Francisco.

The overall reduction of ambient total suspended particulate means that 33 percent fewer people are exposed to annual mean levels in excess of the primary standard. Further improvements in TSP air quality levels are anticipated. The present rate of progress may not be sustained since fewer traditional sources remain to be controlled and since fugitive dust and reentrained urban particulates are more difficult to control.

Even though improvements have been made, a significant ambient TSP problem still remains. The most recent data show that approximately 50 percent of the state and local monitoring stations have annual averages in excess of the secondary annual TSP air quality standard. Approximately 30 percent of the nation's population is still living in areas above the long-term primary annual standard. On July 1, 1976, calls were made for State Implementation Plan (SIP) revisions that would require states to adopt new regulations for areas where problems exist.

To provide a better understanding of the improvement in TSP levels, it is useful to consider the patterns in emissions during the same time period. For the purposes of this report, a brief consideration of emission trends will suffice, but more detailed information is available elsewhere.[5] Emissions may be described as either "potential" or "actual." Potential emissions are those that would have occurred without any controls whereas actual emissions reflect the reductions resulting from controls. The reason for this distinction becomes apparent when one considers the net improvement in TSP levels. During the 1970-1974 period potential emissions of particulates from stationary sources increased an estimated 20 percent from industrial growth. Without additional controls, therefore, TSP levels would not have remained constant but would have deteriorated further. The reason for the observed net improvement in TSP levels is that the degree of control increased from 69 percent to 82 percent during this time so that actual emissions were reduced. In fact, in 1974 approximately 26 million tons per year of particulates was being controlled that was not controlled in 1970.[5]

The data used in the analyses of TSP trends were obtained from EPA's National Aerometric Data Bank. Most of these data are collected by state and local agencies and sent to EPA. This section treats four categories of trends: (1) trends from 1971 to 1975, (2) recent changes in 1974 and 1975, (3) trends in population exposure, and (4) trends in specific cities.

### 3.1.1 TSP TRENDS IN 1971-1975

In order to present a variety of information in one figure, a modified version of the graphical technique known as a Box Plot[6] is used in this section and in the next. These graphs present the 10th, 25th, 50th (median), 75th, and 90th percentiles of the data, as well as the composite average. The 10th and 25th percentiles depict the "cleaner" sites. The 75th and 90th depict the "dirtier" sites, and the median and average describe the "typical" sites. For example, 90 percent of the sites would have concentrations lower than the 90th



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percentile. Also, the ranges of the 10th and 90th percentiles, and the 25th and 75th percentiles indicate what "most" of the sites are doing. Although the average and median both characterize typical behavior, the median has the advantage of not being affected by a few extremely high observations. Figure 3-1 shows how this information is plotted.

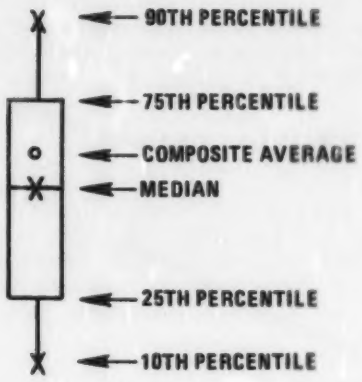


*Figure 3-1. Sample illustration of plotting conventions for box plots.*

In Figure 3-2, the general improvement in TSP levels is seen in all parameters; however, the use of the Box Plot technique highlights the more pronounced improvement in the higher concentration ranges. The cleaner sites are also improving, but the pattern is more stable. The improvement in the composite average is due primarily to decreases at the higher sites rather than to uniform reductions at all sites. This pattern is consistent with the pollution control programs in effect. Those sites that already meet the ambient air quality standards are not so much concerned with further reductions but rather with maintaining their air quality.

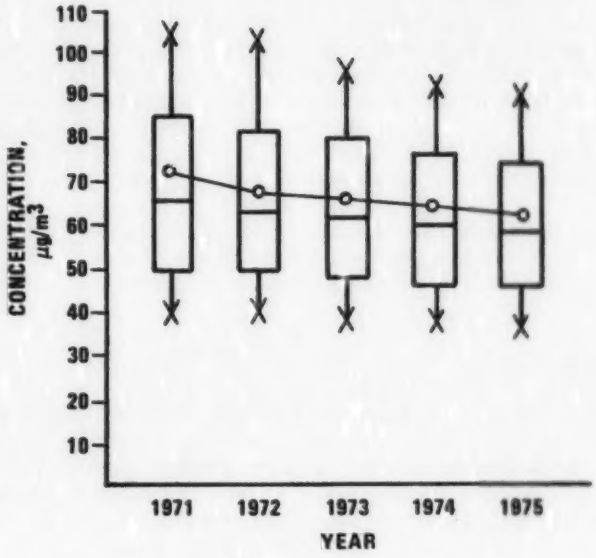


*Figure 3-2. Trends of annual mean total suspended particulate concentrations from 1971 to 1975 at 1792 sampling sites.*

While Figure 3-2 shows year-by-year improvement in TSP levels, Figure 3-3 contrasts the frequency distributions of these sites in 1971 and 1975. The shaded area indicates improvement for all percentiles. For example, in 1971 approximately 37 percent of these sites exceeded the primary standard of 75$\mu g/m^3$, but by 1975 only 23 percent were in excess. A greater percentage of sites in the higher concentration ranges show improvements, and sites in the lower ranges are more stable. Figure 3-4 indicates the percent of sites increasing

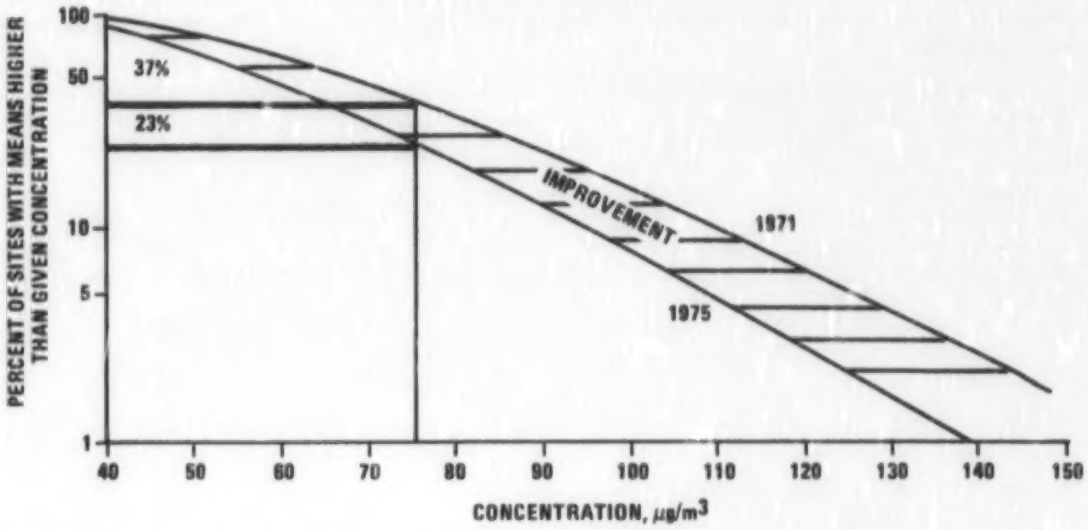


*Figure 3-3. Frequency distributions in 1971 and 1975 for total suspended particulate trend sites (semi-log scale).*

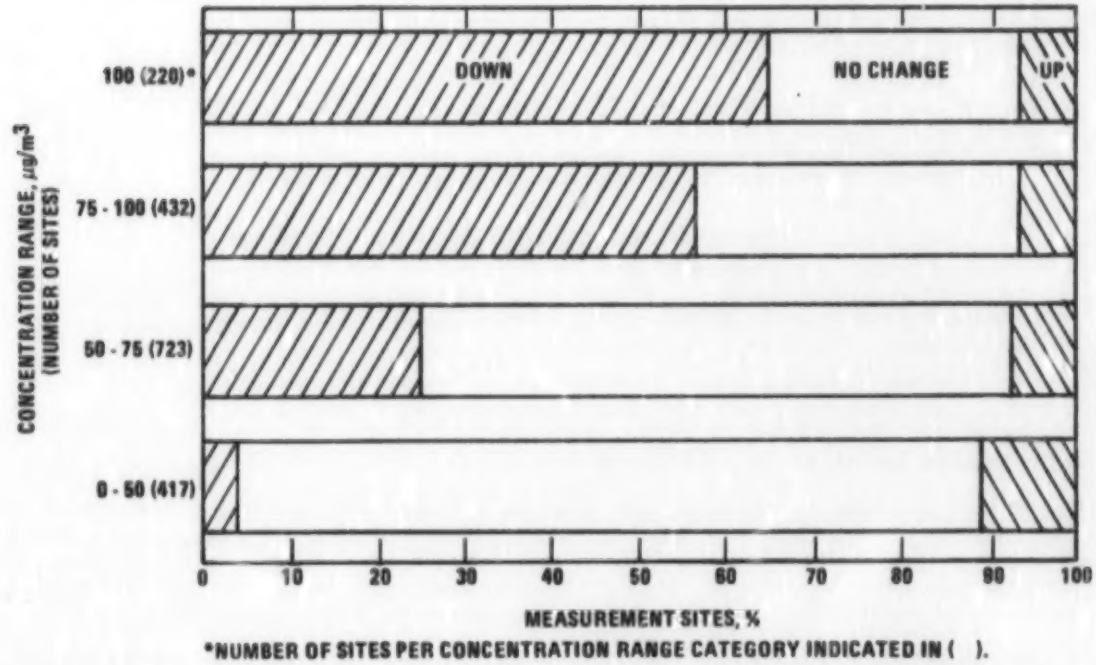


*Figure 3-4. Percent of total suspended particulate sites changing by more than 5$\mu g$, 1971 - 1972 versus 1973 - 1975 by concentration range.*

or decreasing by 5 $\mu g/m^3$ for different concentration ranges. While improvement has been made in all seasons, the first and second quarters have shown the most consistent progress.

Although improvement in TSP levels has occurred throughout broad geographic areas, the West has not followed this general pattern. The median in the West has been fairly stable but the 90th percentile value has been somewhat erratic. This may be due to regional differences in the nature of the TSP problem. In some areas of the West, wind-blown dust is a major determinant of TSP levels. In addition, in areas such as Los Angeles, secondary particulates are important. Neither of these factors is easily controlled by standard particulate control measures.

The improvements discussed so far have been presented in terms of changes in annual mean levels. Another important aspect of the TSP problem is the peak values during the year. During the 1971-1975 time period many sites increased their sampling frequency and thus complicated the analysis of trends in peak values. To compensate for this change, the number of days the primary standard was exceeded was estimated using the lognormal distribution. These formulas are commonly used in air pollution data analysis and are reasonably accurate for TSP.[7] Figure 3-5 was obtained by using the geometric means of the actual data and an assumed standard geometric deviation of 1.6 and 365 days of sampling. Although based upon estimated values, this technique is a convenient means of depicting expected improvement from 1971 to 1975 in terms of peak values.

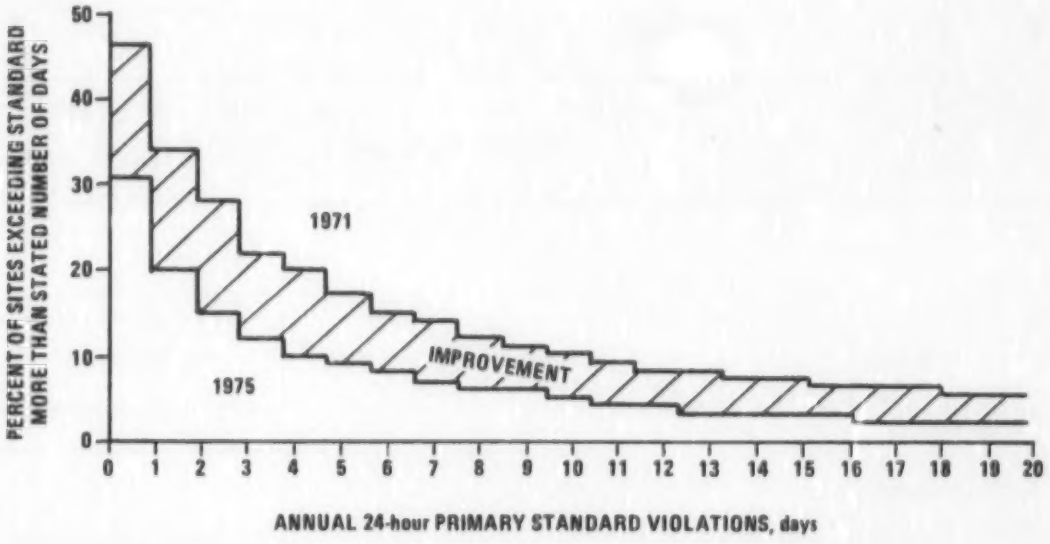


*Figure 3-5. Change in percent of sites in nation exceeding 24-hour primary total suspended particulate standard for a given number of days in 1971 and 1975 (computed using lognormal distribution and standard geometric deviation of 1.6).*

### 3.1.2 Changes in TSP Levels in 1974-1975

Short-term changes in TSP levels would be expected to vary more than the long-term changes because they are likely to be influenced by temporary factors, such as atypical meteorology. One method of summarizing these short-term patterns is to examine the number of sites showing recent increases or decreases. Figure 3-6 presents the percentage of TSP sites that increased by more than 10 percent, decreased by more than 10 percent, or remained unchanged for both means and peak values.

The short-term trends are based on all available quarterly data from mid-1973 through 1975. Comparisons are made between corresponding quarters at individual sites. There were no appreciable differences by season. As shown in Figure 3-6 for short-term trends in mean levels, improvements

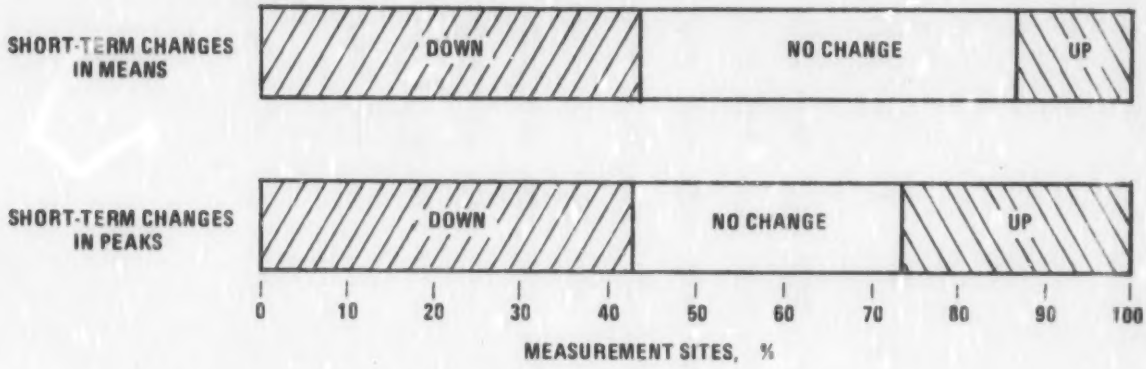


*Figure 3-6. Changes by more than 10% for total suspended particulate during 1974/1975.*

outnumbered increases by more than 3 to 1. For the case of peak values, the short-term trend also shows more decreases than increases.

### 3.1.3 Population Exposure Trends

Section 2 presented trends in population exposure for selected cities. Although this section is primarily concerned with trends in actual air quality, the data base for TSP is sufficiently dense to permit at least a preliminary analysis of nationwide trends in population exposure. The nature of the data base does not lend itself to a detailed analysis as done for selected cities so certain simplifying assumptions were introduced and 1970 census data were used with TSP data from 1970 to 1974. The data are separately examined among counties in Standard Metropolitan Statistical Areas (SMSA) and the total non-SMSA portions of each AQCR. One hundred sixty-four million people were considered to live in areas represented by the approximately 1800 TSP monitors, which had sufficient historical data during the 1970-1974 time period. The percent of population exposed to a given concentration is assumed to be proportional to the percent of monitoring sites at which this concentration is exceeded for each area.

Out of 164 million people considered in this analysis, the portion of the population exposed to concentrations in excess of the primary standard of 75 $\mu g/m^3$ decreased from 45 percent in 1970 to 30 percent in 1974. This trend in reduced nationwide population exposure is pictured in Figure 3-7.

Reduced exposures generally occurred at all concentration levels. This is demonstrated by Figure 3-8, which presents the change in nationwide population exposure for three concentration levels: 60, 75, and 90 $\mu g/m^3$.

### 3.1.4 TSP Trends in Selected Cities

While the previous sections have discussed general trends, the purpose of this section is to highlight specific cities to illustrate the progress made on a local level. Ten cities were chosen on the basis of available historical data and broad geographic representation.

While composite averages show a fairly steady change from year to year, another way to view these same data is shown in Figure 3-9. This figure displays the percent of observations that were above the secondary TSP standard (150 $\mu g/m^3$) in selected areas, emphasizing the effect of control measures on high values. In many cases the improvement is more pronounced than is apparent from the composite average. For example, in the New York City area (N.Y.-N.J.-Conn. AQCR), there were 103 sites during this time period. While the composite average of these sites dropped from 79 to 61 $\mu g/m^3$, the percent of times the secondary standard was exceeded decreased from 7.7 percent to 3.0 percent. Although the composite average showed a 22 percent improvement, the fraction of times the secondary standard was exceeded showed a 61 percent improvement.

Though presentations like Figure 3-9 are useful to indicate relative change within an area, and therefore trends, such a presentation cannot necessarily be used to rank cities. Local monitoring networks may differ

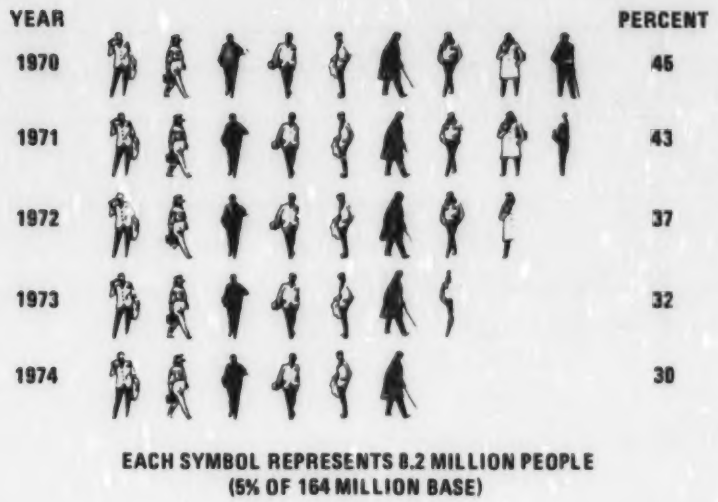


*Figure 3-7. Percent of population exposed to annual mean total suspended particulate in excess of 75 μg/m³ (NAAQS) from 1970 through 1974.*

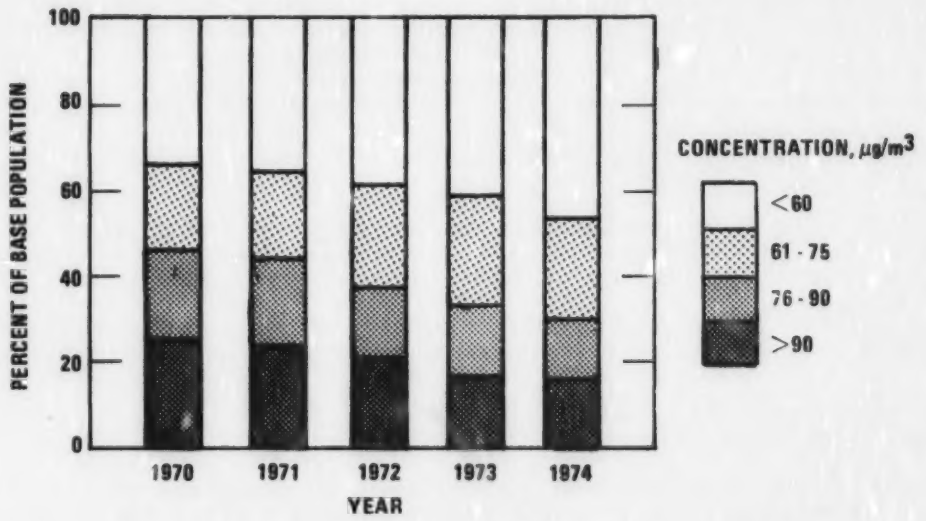


*Figure 3-8. Trend in national population exposure expressed as annual mean total suspended particulate.*

appreciably in character; and within a given area there may be appreciable gradients in pollution levels, as was discussed in section 2.1 for the New York City area.

## 3.2 TRENDS IN SULFUR DIOXIDE

A comparison of the most recent data with those for other recent years sh sulfur dioxide concentrations in urban areas have decreased by an average of 30 percent since 1970. I to TSP levels,

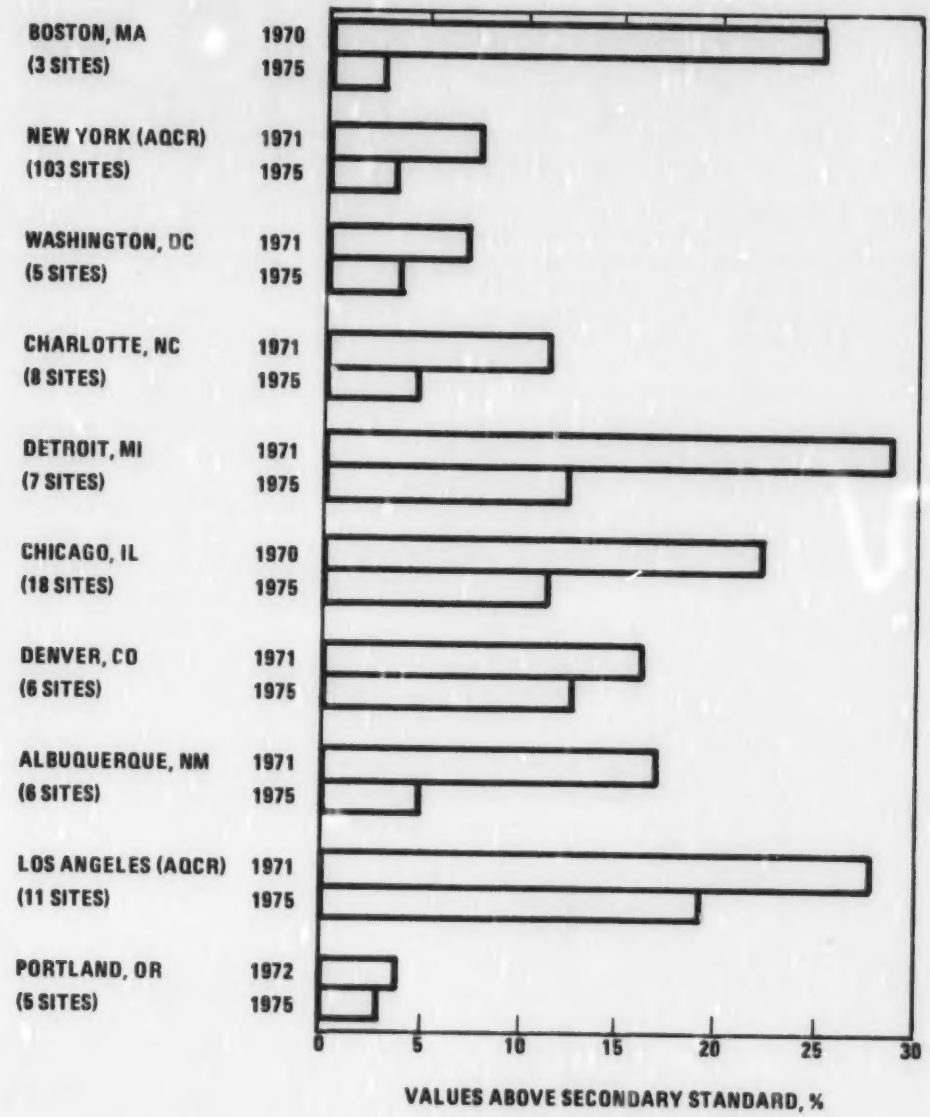


*Figure 3-9. Percent of values above secondary total suspended particulate standard for selected cities.*

which have shown consistent improvement from year to year, sulfur dioxide levels improved rapidly in the 1970-1973 period and then leveled off as many areas came into compliance with the standards. The data available through 1975 indicate that sulfur dioxide levels have been relatively stable for the nation as a whole over the past year. Trends in ambient sulfur dioxide appear to have leveled off or in some cases increased slightly, apparently because of the failure or inability to use clean fuels in some areas of the country. For example, in Los Angeles, ambient sulfur dioxide levels are low but have increased because of recent fuel shifting associated with natural gas curtailments. A similar pattern appears in parts of the Northeast, where, for example, data from Boston show slight increases in ambient sulfur dioxide levels during the past year.

From a national perspective, the urban sulfur dioxide problem has diminished so that only a few monitors in a small number of urban areas are exceeding sulfur dioxide NAAQS. Major point sources located outside of urban areas, such as smelters, pose the greatest threat to violation of sulfur dioxide NAAQS at the present

time. A combination of special-purpose ambient monitoring and modeling indicates that sulfur dioxide NAAQS are being exceeded around many of these sources.

The data used in the analyses of sulfur dioxide trends were selected on the basis of historical completeness during the 1971-1975 time period. As discussed in the overview, there has been nationwide improvement in sulfur dioxide levels during the early 1970's; however, an important aspect nationally is that almost 90 percent of these decreasing-trend sites are in populous areas.

The decreasing trend of sulfur dioxide emissions should not be taken to mean that sulfur dioxide is no longer a problem. What has happened is that the nature of the sulfur dioxide problem in this country has changed in the past few years. In the late 1960's many cities had high sulfur dioxide levels. Pollution abatement has been quite successful in our cities, and sulfur dioxide levels have improved dramatically. In many localities, however, major sulfur oxide sources are located away from urban areas. Sulfur dioxide levels around these sources are not adequately reflected in the trend data base. Thus, the downward trends in sulfur dioxide represent only one part of the total picture. Although substantial improvement has been generally made in the more heavily populated areas, sulfur dioxide is still a problem in some areas.

In many cases, the isolated nature of these non-urban sources makes long-term trend monitoring difficult. In general, the primary concern with these sources is to monitor the surrounding air for compliance with the applicable air quality standards. This can be done effectively through special studies at much lower cost than would be required to maintain trend sites continuously for several years. Moreover, such long-term trend sites would yield information only for one particular source and be of limited use in assessment of pollution nationwide.

### 3.2.1 Sulfur Dioxide Trends (1971-1975)

The Box Plot technique was also used to illustrate sulfur dioxide trends during the 1971-1975 period (Figure 3-10). For sulfur dioxide the general stabilization is much more pronounced. Despite the overall improvement in ambient sulfur dioxide levels, it is evident that a leveling off has occurred during the past few years. The use of the Box Plot technique, however, reveals fairly consistent progress for the sites measuring higher concentrations. This is emphasized by the decreasing size of the boxes in successive years as the range of sulfur dioxide concentrations decreases. This stabilization of sulfur dioxide at relatively low levels is evidence

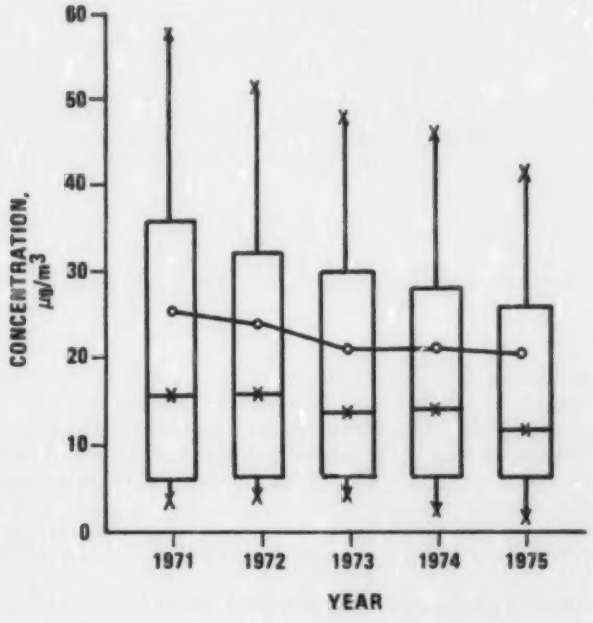


*Figure 3-10. Sulfur dioxide trends 1971-1975 (545 sites), annual averages.*

of the progress made in abatement of sulfur oxide emissions in cities across the nation. As would be expected, the majority of sites showed improvement during this time period. If only those sites with annual averages greater than 50 percent of the sulfur dioxide standard in 1971-1972 are considered, the results are even more striking. Over 80 percent of these sites showed improvement during this time period.

Figure 3-11 shows the 90th percentiles for various geographical areas during the 1971-1975 period. The West is omitted from this graph because it had only 33 sites. (The Los Angeles area is discussed as one of the "selected cities.") The 90th percentiles for regions except the West indicate the general sulfur dioxide improvement during this period. This figure also points out the higher levels in the northern cities due to emissions associated with space heating.

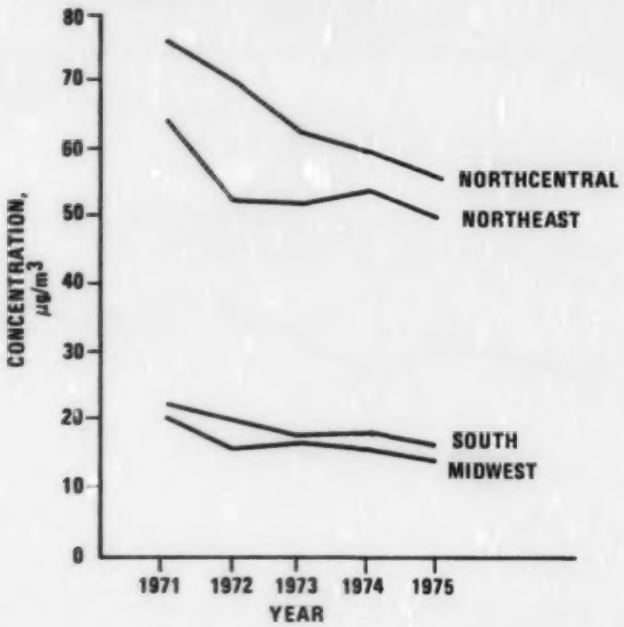


*Figure 3-11. 90th percentile trends for sulfur dioxide by geographical region (1971-1975).*

### 3.2.2 Recent Changes in Sulfur Dioxide Levels

Figure 3-12 summarizes the number of increases and decreases in sulfur dioxide levels during the past 2 years for quarterly means and peak values. In both cases, more sites showed improvement rather than increases, but the number of sites with no change prevented the emergence of any overall trend. However, for those sites with values greater than 50 percent of the primary sulfur dioxide standards, the majority show short-term improvement in both means and peak levels.

### 3.2.3 Sulfur Dioxide Trends in Selected Cities

Because of the recent increases and decreases in sulfur dioxide levels nationally, it is useful to present the patterns in selected areas in more detail. This is done in Figure 3-13 for the Standard Metropolitan Statistical Areas with the most sites in each geographical region. This graph illustrates the varied patterns in trends in the following categories: continued improvement (Chicago), general improvement but currently stable (Houston), stable (Nashville), overall general improvement but evidence of trend reversal (Boston), and general increase (Los Angeles). The major problem for cities is the availability of low-sulfur fuels. In certain areas increases in sulfur dioxide have been anticipated because of insufficient supplies of low sulfur fuels.

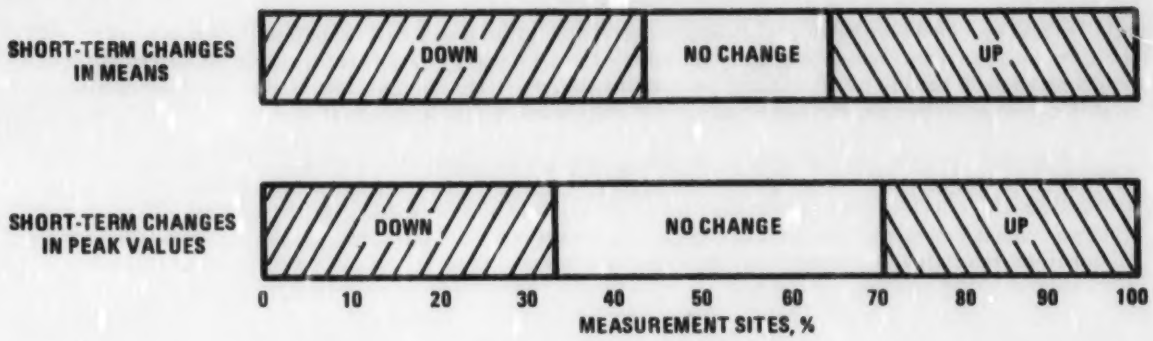


*Figure 3-12. Recent changes by more than 10% for sulfur dioxide (1974/1975).*

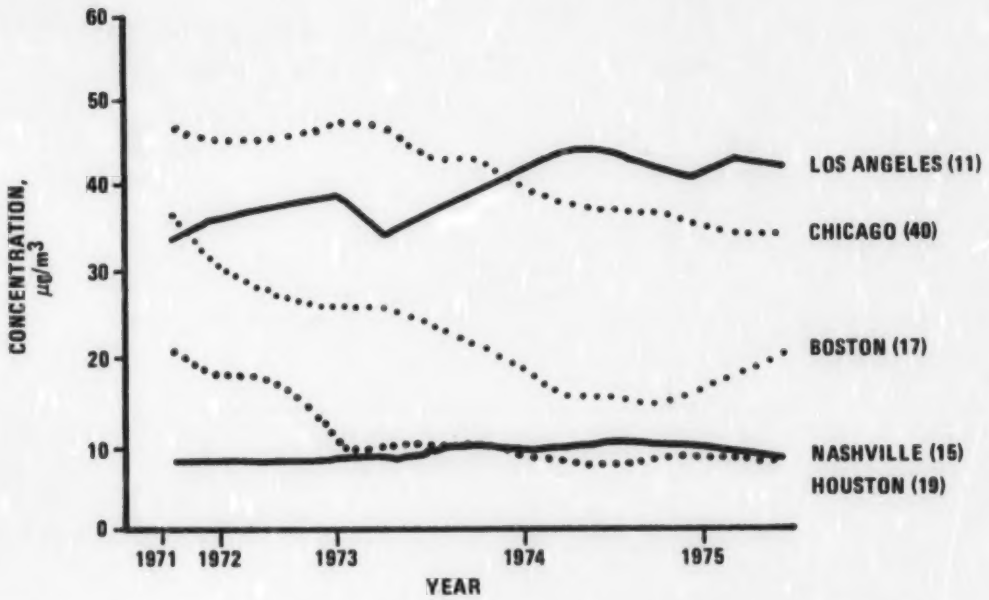


*Figure 3-13. Composite average sulfur dioxide trends (and number of sites) for dominant SMSA's in each region.*

## 3.3 TRENDS IN CARBON MONOXIDE

The primary source of carbon monoxide (CO) emissions in most cities is the automobile. Nationally, approximately 75 percent of the CO emissions are attributed to transportation sources; but in certain areas, such as Los Angeles, these sources may contribute as much as 99 percent. Any location with sufficient traffic density may be viewed as having a potential CO problem. The problem may be very localized, perhaps at just a few street corners, or it may be widespread throughout the center-city area and near major commuter corridors. Improvements in ambient CO levels are directly related to the control of automotive emissions.

### 3.3.1 Data Base and Trend Techniques

As indicated in previous reports[3,4] historical data for CO are inadequate to assess national trends. For this analysis, all CO data from EPA's National Aerometric Data Bank were screened to select sites having

current data. Any site with 4,000 or more hourly values (out of a possible 8760 per year) for at least 3 years was used if it also had data from 1975. As a result of this screening process, 102 sites were selected from 24 states. Of these, 42 were located in California, which is indicative of the well-established air quality monitoring program in that state. More than half (34 out of 60) of the sites outside California had data for only 3 years. Because 3 years of data are usually not sufficient to characterize trends, the approach used in this analysis is to examine the patterns of groups of sites to present a general picture of CO trends rather than concentrating on specific sites. Non-parametric regression[8] was used to assess the sign of the trend at each site, as well as the significance level. The 90th percentile of the 8-hour CO data was used to reflect peak concentrations and yet introduce more stability than the maximum or second highest value. In addition, the 8-hour average primary CO standard is the one that is most frequently violated.

### 3.3.2 CO Trends From 1970 to 1975

CO trends are evaluated by presenting the results for the State of California and comparing these patterns with those from the rest of the nation. In this way, the extensive California data base provides a convenient frame of reference for CO trends on the national level.

The CO trends for California are summarized in Table 3-1, and those for the rest of the nation are shown in Table 3-2. In both cases, the overall picture clearly indicates improvement. For those sites with data for 3 or more years, the 81 percent improvement of the California sites agrees closely with the 78 percent showing improvement for the rest of the country.

**Table 3-1. NUMBER AND PERCENT OF CALIFORNIA MONITORING SITES SHOWING INDICATED TRENDS IN 90TH PERCENTILE OF 8-HOUR AVERAGE CO CONCENTRATIONS, 1970-1975**

| Years of data | Down | No change | Up | Total |
|---|---|---|---|---|
| 5 or more | 14 (70%) | 2 (10%) | 4 (20%) | 20 |
| 4 or more | 27 (79%) | 2 (6%) | 5 (15%) | 34 |
| 3 or more | 34 (81%) | 2 (5%) | 6 (14%) | 42 |

**Table 3-2. NUMBER AND PERCENT OF NON-CALIFORNIA MONITORING SITES SHOWING INDICATED TRENDS IN 90TH PERCENTILE OF 8-HOUR AVERAGE CO CONCENTRATIONS, 1970-1975**

| Years of data | Down | No change | Up | Total |
|---|---|---|---|---|
| 5 or more | 12 (75%) | 0 | 4 (25%) | 16 |
| 4 or more | 20 (77%) | 0 | 6 (23%) | 26 |
| 3 or more | 47 (78%) | 0 | 13 (22%) | 60 |

Because of the variability associated with trends based upon only 3 years of data, more meaningful conclusions can be drawn from those sites with 4 or more years of data. As shown in the tables, the percent of sites showing improvement is still in close agreement (79 percent and 77 percent) and basically the same as for all data. The California trends are much more pronounced; 44 percent of the sites have statistically significant improvements, as opposed to 27 percent for the rest of the nation. Also, the rate of improvement appears greater in California with a median rate of around 7 percent per year versus 5 percent for the rest of the nation. The general applicability of these median rates is limited by the extent of the data bases, but they do illustrate

that the California trends are more pronounced. With respect to trends in the rest of the nation, there was no particular geographical clustering, and all areas of the country had sites showing improvement.

Another way of determining CO levels is to measure the carboxyhemoglobin level in the blood of people breathing air polluted with CO. In a sense, the blood of each individual provides an indicator of his or her exposure to CO. Reductions in CO emissions should reduce carboxyhemoglobin body-burden in the general public. Although these types of data are limited, there have been studies of carboxyhemoglobin levels in blood donors.[9]

Trends for Chicago using 1970 and 1974 CO emissions were compared with the mean percent carboxyhemoglobin for nonsmokers for the same time frame. Carboxyhemoglobin was reduced by 25 percent (2.04 to 1.53 percent and the weighed average CO emissions declined by 22.8 percent.[10,11] This relatively close agreement suggests that the CO emission controls are being effective in improving carboxyhemoglobin levels in the general public.

## 3.4 TRENDS IN OXIDANTS

The extensive monitoring network of the State of California is reflected in the trend analysis that follows. Analysis of trends in other parts of the country is impaired by changes in analytical methods, the change from measuring total oxidants to ozone, or the lack of a monitoring network. Oxidant data for many years were examined for the Los Angeles Basin, the San Francisco Bay Area, and the San Diego Basin. For areas outside of California, recent oxidant/ozone trends (1973-1975) were examined.

### 3.4.1 Data Base and Trend Techniques

For the Los Angeles Basin, five parameters were used to characterize Basinwide oxidant trends: (1) third-quarter average of hourly data, (2) annual average of daily maximum 1-hour data, (3) the number of days when levels exceeded the Federal Episode Alert Criteria for oxidants of 200 $\mu g/m^3$, (4 and 5) the numbers of third-quarter days exceeding two and three times the NAAQS for oxidants of 160 $\mu g/m^3$. Oxidant trends in San Francisco are based on the average daily maximum value for days with comparable meteorology during the oxidant season. For the San Diego Basin, the annual average of daily maximum 1-hour data was used to characterize oxidant trends. Data for these analyses were obtained from EPA's National Aerometric Data Bank and supplemented by publications of the Los Angeles Air Pollution Control District,[12-14] the San Diego Air resources Board,[15] and the Bay Area Air Pollution Control District.[16]

### 3.4.2 Oxidant Trends in California

The trends in oxidants in California are presented for the most recent 5 years (1971 to 1975) and for longer periods up to 10 years. For the Los Angeles Basin, oxidant trends are summarized in Tables 3-3 through 3-6. The data indicate long-term improvement, with average high-hour oxidant levels declining 31 percent and average third-quarter concentrations dropping 23 percent.

**Table 3-3. SUMMARY OF TRENDS IN ANNUAL AVERAGE OF DAILY 1-HOUR MAXIMUM OXIDANT LEVELS IN LOS ANGELES BASIN**

| Length of data record | Number of sites | | | |
|---|---|---|---|---|
| | Down | No change | Up | Total |
| 5 years (1971-1975) | 3 (22%)[a] | 5 | 1 (7%) | 9 |
| 10 years (1966-1975) | 9 (31%) | 0 | 0 | 9 |

[a]Numbers in parentheses are percent change in concentration between base year and 1975.

Since 1971, however, the improvement is not so pronounced. Even though annual average daily maximum levels have declined 22 percent, fewer sites have declined (3 versus 9) in the 5-year versus the 10-year period. Also, third-quarter average levels have remained unchanged between 1971 and 1975. Similarly, there

**Table 3-4. SUMMARY OF TRENDS IN THIRD-QUARTER AVERAGE OF DAILY 1-HOUR OXIDANT LEVELS IN LOS ANGELES BASIN**

| Length of data record | Number of sites | | | |
|---|---|---|---|---|
| | Down | No change | Up | Total |
| 5 years (1971-1975) | 0 | 3 | 0 | 9 |
| 9 years (1967-1975) | 6 (23%) | 3 | 0 | 9 |

**Table 3-5. SUMMARY OF TRENDS IN NUMBER OF DAYS 1-HOUR OXIDANT LEVELS EXCEEDED 200 $\mu g/m^3$ BY QUARTER IN LOS ANGELES BASIN**

| Length of data record | Quarter | | | | Annual |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | |
| 5 years (1971-1975) | no change | no change | no change | no change | no change |
| 10 years (1966-1975) | down | down | no change | down | down |

**Table 3-6. SUMMARY OF TRENDS IN NUMBER OF THIRD-QUARTER DAYS 1-HOUR OXIDANT LEVELS EXCEEDED TWO AND THREE TIMES NAAQS FOR OXIDANT IN LOS ANGELES BASIN, 1970-1975**

| | Number of sites | | | |
|---|---|---|---|---|
| | Down | No change | Up | Total |
| 2 X NAAQS | 3 | 8 | 0 | 11 |
| 3 X NAAQS | 2 | 8 | 1 | 11 |

is a long-term decline in the total number of days exceeding 200 $\mu g/m^3$ (0.10 ppm) annually, but there is no change in the past 5 years. While no long-term or short-term change has occurred in the number of third-quarter days in violation of the 200-$\mu g/m^3$ alert level, some improvement has occurred at higher concentration levels, as indicated by Table 3-6. This is important since the third quarter is the season of greatest photochemical activity and highest 1-hour oxidant concentrations.

The overall 10-year decline in oxidant levels and the absence of a trend in the recent 5-year data may be explained by examining hydrocarbon emission trends and meteorological conditions. The annual number of days with poor atmospheric ventilation 12 (mixing) in the Basin is shown in Figure 3-14. The figure reveals that during the period 1966 through 1970 an above normal number of days had poor ventilation, but beginning in 1971 the cycle reversed and fewer than normal of these days occurred. Superimposed upon this is the steady reduction of reactive hydrocarbon emissions[12] seen in Figure 3-14. The results of correlating the observed meteorology and emissions with the annual average of daily maximum 1-hour oxidants and the number of days above 200 $\mu g/m^3$ are shown in Table 3-7. The 10-year oxidant trend is, then, partially explained by hydrocarbon emissions and atmospheric ventilation. Emissions were found to account for at least twice as much of the oxidant trend as the meteorology.

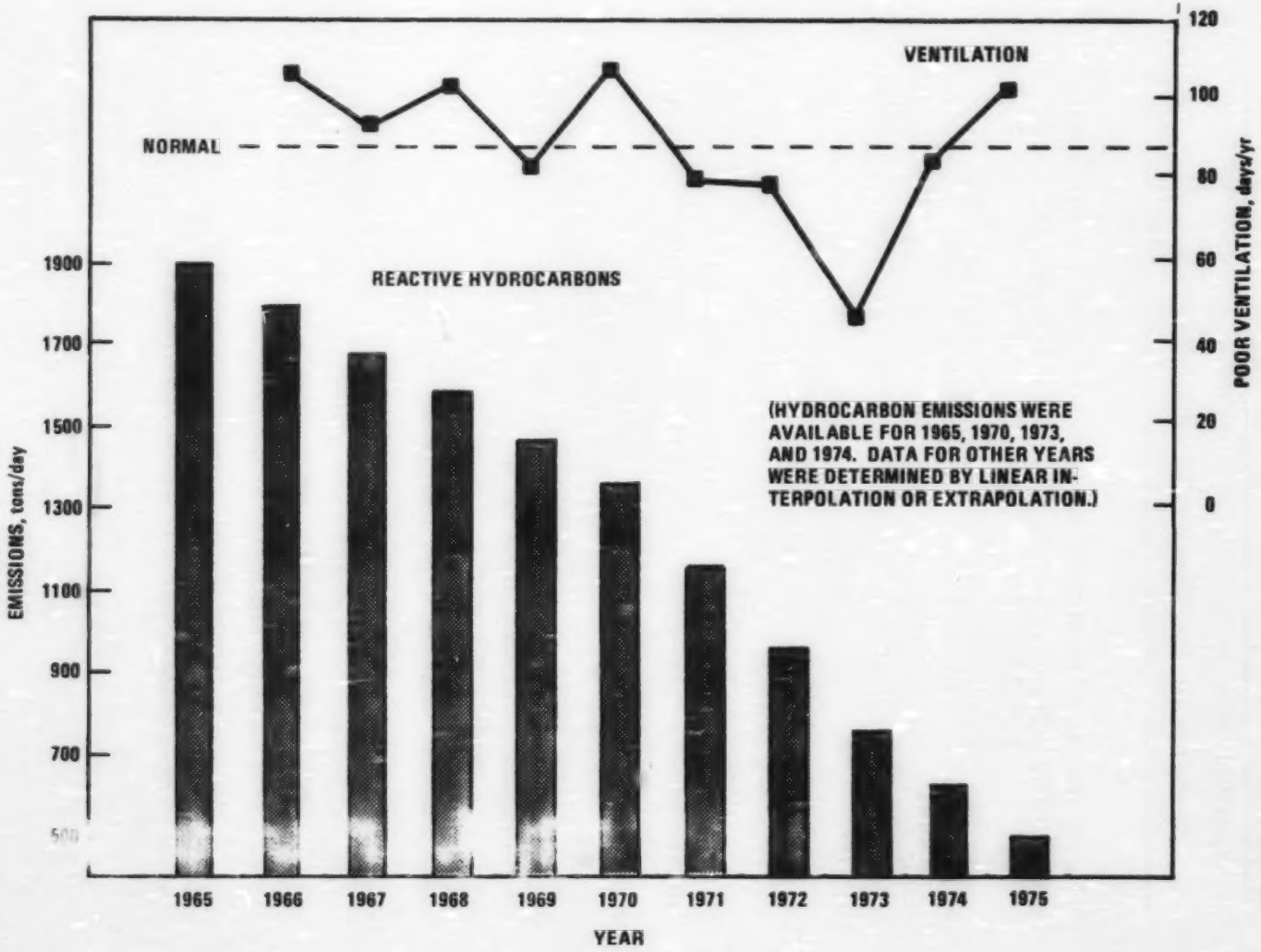


*Figure 3-14. Atmospheric ventilation and reactive hydrocarbon emissions in Los Angeles County over 10-year period.*

**Table 3-7. PERCENT OF OXIDANT TRENDS DUE TO ATMOSPHERIC DISPERSION AND REACTIVE HYDROCARBON EMISSIONS IN LOS ANGELES, 1966-1975**

| Area of Basin | Percent |
|---|---|
| Azusa - Pasadena - Pomona [a] | 91 |
| Burbank - Reseda [a] | 80 |
| Los Angeles, downtown - West Los Angeles [a] | 78 |
| Lennox - Long Beach [a] | 91 |
| Basinwide [b] | 95 |

[a] Annual average of daily 1-hour maximum oxidant concentrations.

[b] Annual number of days oxidant levels exceeded 200 $\mu g/m^3$.

The observed oxidant levels were adjusted for abnormal meteorology using a simple linear model. Examples of the observed and adjusted trends in Figure 3-15 indicate that adjusting for the meteorology tends to smooth oxidant trends to follow emission trends more closely. Looking at the meteorological data in Figure 3-14, it can be seen that atmospheric ventilation induced higher oxidant levels between 1966 and 1970 and lower oxidant levels from 1971 through 1974.

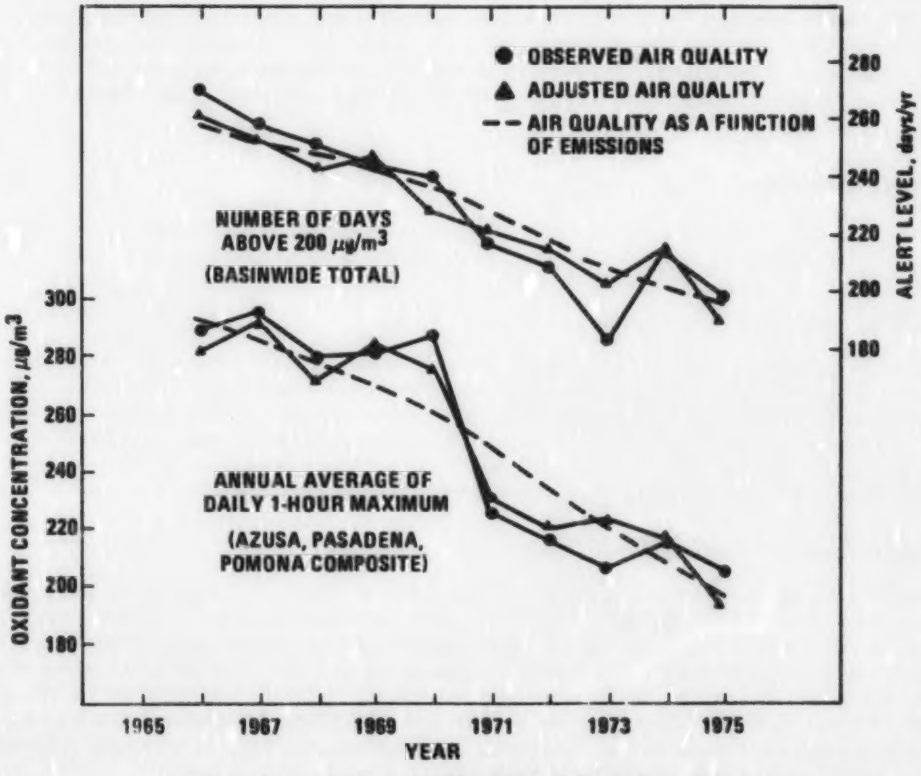


*Figure 3-15. Oxidant trends adjusted for meteorology.*

Comparing the observed and adjusted oxidant levels reveals that abnormal meteorology has altered annual oxidant levels up to 14 percent per year in 1972 and about 2.5 percent for the 10-year period. The analysis shows how recent meteorological patterns may have masked the continuous decline in oxidant levels during the past 5 years and thus have caused the lack of any trend at many sites during this period.

Table 3-8 summarizes both long- and short-term oxidant trends in the San Francisco Bay Area for days with comparable meteorology during the oxidant seasons. The data were obtained from a report prepared by the Bay Area Air Pollution Control District.[16] Restricting the analysis to days with similar temperature and inversion conditions minimizes the effect of year-to-year variation due solely to meteorology. As shown in Table 3-8, all long-term trends and five of the seven short-term trends indicate improvement. Although there are two short-term increases, neither is statistically significant. All but one of the 13-year improvements were significant. Oxidant trends in the San Diego Basin are summarized in Table 3-9. In this region of California, annual average daily oxidant maxima declined 40 percent during the past 10 years; however, recent increases nearly equal recent declines. No change has, therefore, occurred during the past 5 years in the San Diego Basin.

### 3.4.3 Oxidant/Ozone Trends in Areas Outside of California

Ten states outside of California contain sites with at least 3 consecutive years of current oxidant/ozone data. Although 3 years of data are insufficient to determine trends at a specific location, the data may provide information on the tendency of trends in oxidant/ozone level.

For this analysis, third-quarter oxidant data were analyzed at 21 sites in the ten states where sufficient data are available. Only third-quarter data were analyzed since this represents the season of highest photochemical activity. The percent of days when the oxidant/ozone standard (160 $\mu g/m^3$ 1-hour value) was equalled or exceeded was used to reflect the frequency of violations and yet provide more stability than either the percent of hours exceeding the standard or the maximum and second-high value. A non-parametric regression technique was used to indicate the sign of the trend and significance level at each site.

Although none of the trends were statistically significant, as might be expected from the limited amount of data, a geographic clustering of similar trend signs is apparent. The results indicate a decreasing tendency in summer oxidant ozone violations in the eastern cities (8 sites down, 3 sites up) and an increase at sites in the Denver area (5 sites up). Unfortunately, the limited number of sites precludes any firm conclusions about regional trends. The analysis does provide, however, an initial oxidant/ozone data base, which will continue to grow as more years of data become available.

## 3.5 TRENDS IN NITROGEN DIOXIDE

Examination of existing nitrogen dioxide data for potential trend sites indicates that sufficient data are available for trend evaluations at sites in California, New Jersey, Illinois, Colorado, and Oregon.

### 3.5.1 Data Base and Trend Techniques

For the Los Angeles Basin, three parameters were used to characterize Basinwide nitrogen dioxide trends: annual average of hourly data, annual average of daily maximum 1-hour data, and the number of days when nitrogen dioxide levels exceeded the State of California 1-hour nitrogen dioxide standard of 470 $\mu g/m^3$ (0.25 ppm). The annual average of daily maximum 1-hour data was examined in the San Diego Basin, while the annual mean of nitrogen dioxide was used for the San Francisco Bay Area and all sites outside California. The California data were obtained from the same sources as the oxidant data in section 3.4 [12-15]

### 3.5.2 Nitrogen Dioxide Trends in California

In the Los Angeles Basin, trends in all three parameters indicate an overall Basinwide decline in nitrogen dioxide during the period 1971 through 1975. Figures 3-16 and 3-17 show the decline in the Basinwide mean of the annual average of all hourly data and the annual average of daily maximum values, respectively. A long-term decline in the geographic variability of nitrogen dioxide levels is also evident. The number of days exceeding the California short-term standard does not show as clear a trend. The minimum for the period 1965 through 1975 was reached in 1973; however, since then there has been an increase of about 10 days per year. This rise is mainly attributable to increases during the fourth quarter, which is the season of high daily nitrogen dioxide concentrations at most sites in the Basin.

**Table 3-8. AVERAGE HIGH-HOUR OXIDANT CONCENTRATIONS FOR DAYS WITH COMPARABLE TEMPERATURE AND INVERSION CONDITIONS (APRIL THROUGH OCTOBER OXIDANT SMOG SEASONS, 1962-1974)[16]**

| Monitoring stations | Average high-hour oxidant concentration (KI), ppm | | | | | | | | | | | | | | Oxidant trend direction | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 13 yr | 1970-74 only | All data |
| San Francisco (SF) | 0.14 | 0.12 | 0.15 | 0.09 | 0.08 | 0.08 | 0.05 | 0.04 | 0.07 | 0.05 | 0.03 | 0.04 | 0.05 | 0.08 | - (NS)[a] | (ND)[a] |
| San Leandro (SL) | 0.13 | 0.16 | 0.19 | 0.19 | 0.14 | 0.12 | 0.11 | 0.12 | 0.12 | 0.11 | 0.10 | 0.11 | 0.10 | 0.13 | - (NS) | (ND) |
| San Jose (SJ) | 0.11 | 0.17 | 0.14 | 0.16 | 0.11 | 0.13 | 0.13 | 0.13 | 0.12 | 0.08 | 0.10 | 0.11 | 0.16 | 0.13 | +(NS) | -(NS) |
| Redwood City (RC) | 0.13 | 0.10 | 0.10 | 0.14 | 0.10 | 0.09 | 0.08 | 0.09 | 0.08 | 0.07 | 0.08 | 0.07 | 0.07 | 0.09 | - (NS) | (ND) |
| Walnut Creek (WC) | 0.10 | 0.11 | 0.10 | 0.11 | 0.10 | 0.13 | 0.10 | 0.13 | 0.09 | 0.09 | 0.09 | 0 08 | 0.08 | 0.10 | (ND) | (ND) |
| San Rafael (SR) | 0.08 | 0.09 | 0.07 | 0.08 | 0.07 | 0.07 | 0.06 | 0.07 | 0.08 | 0.07 | 0.05 | 0.05 | 0.06 | 0.07 | - (NS) | (ND) |
| BAAPCD[b] average | 0.12 | 0.12 | 0.13 | 0.13 | 0.10 | 0.10 | 0.9 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.09 | 0.10 | - (NS) | (ND) |
| Livermore[c] | (ND) | (ND) | (ND) | (ND) | (ND) | 0.13 | 0.18 | 0.18 | 0.13 | 0.11 | 0.09 | 0.12 | 0.13 | 0.13 | +(NS) | -(NS) |

[a]NS - Not Significant, ND - No Data

[b]For Benchmark stations above with 13 years of record.

[c]Station with 8 years of record.

**Table 3-9. SUMMARY OF TRENDS IN ANNUAL AVERAGE OF DAILY MAXIMUM 1-HOUR OXIDANT LEVELS IN SAN DIEGO AIR BASIN**

| Length of data record | Down | No change | Up | Total |
|---|---|---|---|---|
| 5 years (1971-1975) | 1 (35%) | 1 | 1 (36%) | 3 |
| 10 years (1966-1975) | 3 (40%) | 0 | 0 | 3 |

[a]Numbers in parentheses are present change in concentration between the base year and 1975.

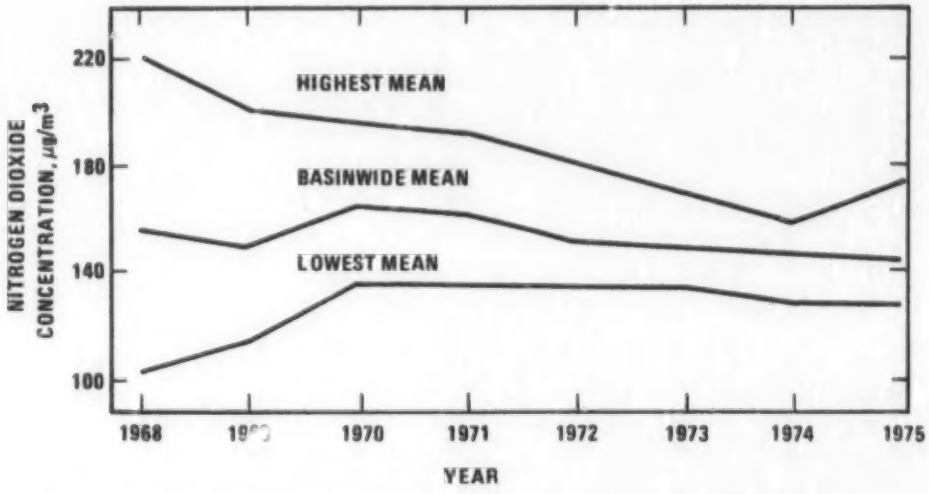


*Figure 3-16. Annual mean nitrogen dioxide levels in the Los Angeles Basin.*

Examination of the annual average nitrogen dioxide concentrations at six sites in the San Francisco Bay Area indicates that increases equalled declines during the period 1971 through 1975. Mean nitrogen dioxide levels during these years remained at about 50 $\mu g/m^3$, which is half of the NAAQS for nitrogen dioxide. In the San Diego Basin the annual average of daily maximum nitrogen dioxide at the downtown site indicates no significant trend in nitrogen dioxide between 1971 and 1975.

### 3.5.3 New Jersey, Colorado, Illinois, and Oregon

The annual average nitrogen dioxide concentrations were examined for three sites in New Jersey for the period 1969 to 1975. The most striking feature of the data is the reduction in nitrogen dioxide levels from mid-1973 through mid-1975 at the high concentration sites: Newark, Bayonne, and Camden. These improvements may be a reflection of the 1973-1974 fuel crisis coupled with the 1974-1975 economic recession. Both events may have been responsible for reduced emissions in these cities. The decline in nitrogen dioxide levels between 1971 and 1975 is shown in Figure 3-18. Trends for these cities project levels below the annual standard for New Jersey.

Recent annual average nitrogen dioxide trends in Denver are similar to trends at the New Jersey sites. The 39 percent decrease from mid-1973 through mid-1975 in Denver is comparable to the 39 percent decrease in Bayonne and the 26 percent decrease in Newark during the same period. In contrast, long-term trends in Portland, Oregon, show a steady increase in nitrogen dioxide concentrations during 1972 and 1973. Evidently, the increase was temporarily interrupted during the 1973-1974 fuel crisis since nitrogen dioxide

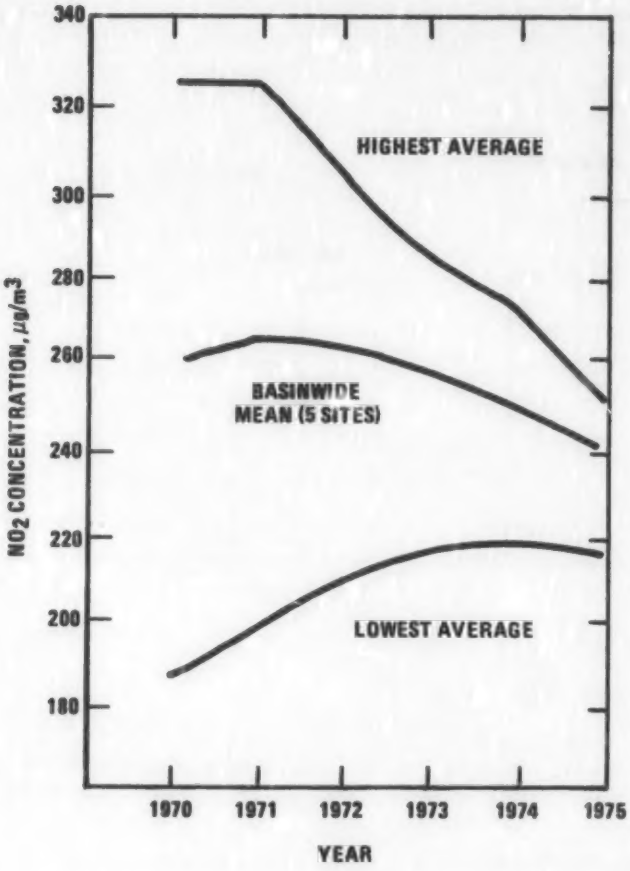


*Figure 3-17. Annual average of daily maximum 1-hour $NO_2$ (4-year running mean) in the Los Angeles Basin.*

levels receded in early 1974. Recent data indicate a return to higher concentrations, although levels are still far below the annual standard. With only slightly more than 4 years of data, it is difficult to see clearly whether emission trends or meteorology are most affecting nitrogen dioxide levels in Portland. At the Chicago Continuous Air Monitoring Program (CAMP) site nitrogen dioxide levels have fluctuated considerably since 1969. No clear long-term trend is evident, but concentration levels at this site remain above the annual standard.

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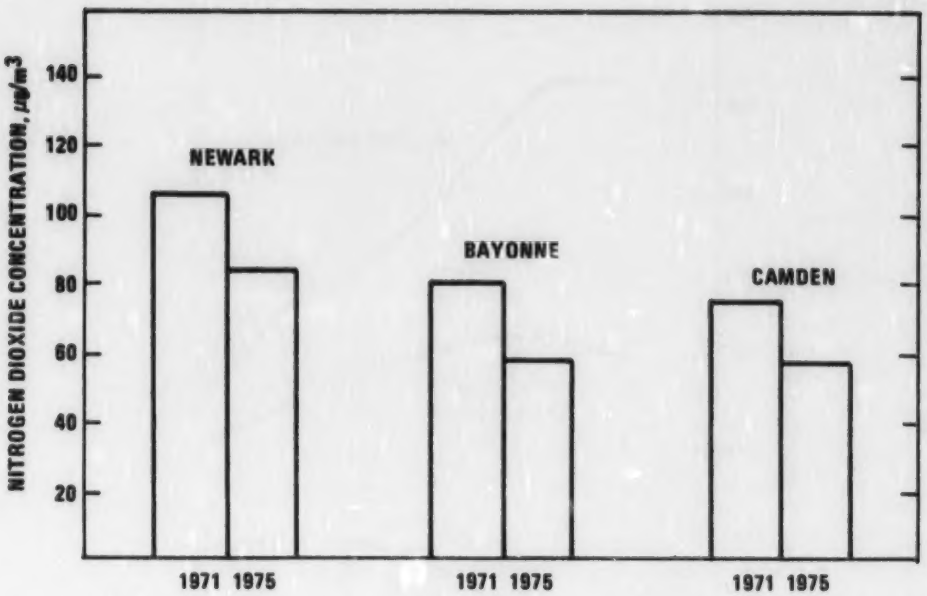


*Figure 3-18. Comparison of 1971 and 1975 annual mean levels of nitrogen dioxide in New Jersey.*


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# 4. NATIONWIDE EMISSION ESTIMATES, 1970-1975

Estimates of nationwide emissions for 1970 through 1975 were determined from newly calculated, internally consistent sets of figures based on the most current emission factors and on a more inclusive list of source categories than those previously used.[1] Consequently, the emission estimates presented here supercede any previously published estimates for the years since 1970.[2] Obviously, previously published estimates of emissions for years prior to 1970 will also lack strict continuity with these figures for the 1970 through 1975 period.

Table 4-1 summarizes the total emissions for particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide from 1970 through 1975. Tables 4-2 through 4-7 summarize each of the pollutants on a yearly basis and identify the major categories and several subcategories responsible for significant contributions to the national totals.

**Table 4-1. SUMMARY OF NATIONAL EMISSION ESTIMATES, 1970-1975**

($10^6$ tons/yr)

| Year | Particulates | $SO_x$ | $NO_x$ | HC | CO |
|---|---|---|---|---|---|
| 1970 | 26.8 | 34.2 | 22.7 | 33.9 | 113.7 |
| 1971 | 24.9 | 32.3 | 23.4 | 33.3 | 113.7 |
| 1972 | 23.4 | 36.7 | 24.6 | 34.1 | 115.8 |
| 1973 | 21.9 | 35.6 | 25.7 | 34.0 | 111.5 |
| 1974 | 20.3 | 34.1 | 25.0 | 32.9 | 103.3 |
| 1975 | 18.0 | 32.9 | 24.2 | 30.9 | 96.2 |

Two distinctions between these emission estimates and ambient pollutant measurements should be noted. First, the emission estimates for particulates, sulfur oxides, and nitrogen oxides embrace a broader range of substances than are measured by routine ambient air monitoring equipment. The high-volume air sampler collects only the particulates suspended in air that range from approximately 0.3 to 100 micrometers in diameter, while emission inventories include all man-made particulates, suspended and settled. Sulfur dioxide and nitrogen dioxide ambient air monitors measure only those two specific compounds, not all the oxides of sulfur and nitrogen included in the emission estimates. In each case, however, the compound actually measured is the most prevalent constituent of its pollutant class or is acknowledged to be its most representative indicator. Second, the tables of estimated emissions include hydrocarbons but not oxidants. Obviously, oxidant emissions would not be meaningful because the overwhelming majority of oxidants are so-called secondary pollutants generated by photochemical reactions in the atmosphere. Emissions of hydrocarbons are important because hydrocarbons are a major ingredient for those oxidant-producing reactions; yet, ambient measurements of hydrocarbons are not reported because a reliable method has not yet been developed for the continuous monitoring of this large and diverse class of compounds. Consequently, monitoring is not required.

## 4.1 EMISSION TRENDS

Particulate emissions from 1970 to 1975 (Figure 4-1) have been reduced primarily because of installation of control equipment on industrial processes, a decrease in coal combustion by non-utility stationary sources, installation of control equipment by electric utilities that burn coal, and a decrease in the burning of solid wastes. The extent of the emission reduction by industrial processes is increased as the result of economic



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**Table 4-2. NATIONWIDE EMISSION ESTIMATES, 1970**

($10^6$ tons/yr)

| Source category | Particulates | $SO_x$ | $NO_x$ | HC | CO |
|---|---|---|---|---|---|
| Transportation | 1.3 | 0.7 | 9.3 | 14.1 | 88.0 |
| Highway | 0.8 | 0.3 | 7.0 | 12.3 | 77.4 |
| Non-highway | 0.5 | 0.4 | 2.3 | 1.8 | 10.6 |
| Stationary fuel combustion | 9.7 | 26.6 | 12.3 | 1.6 | 1.5 |
| Electric utilities | 4.5 | 19.2 | 5.7 | 0.1 | 0.2 |
| Other | 5.2 | 7.4 | 6.6 | 1.5 | 1.3 |
| Industrial processes | 13.6 | 6.7 | 0.6 | 3.6 | 11.5 |
| Chemicals | 0.3 | 0.8 | 0.2 | 1.8 | 4.3 |
| Petroleum refinning | 0.1 | 0.7 | 0.3 | 0.8 | 2.2 |
| Metals | 2.0 | 4.5 | 0 | 0.2 | 3.7 |
| Mineral products | 8.4 | 0.6 | 0.1 | 0 | 0 |
| Other | 2.8 | 0.1 | <0.1 | 0.8 | 1.3 |
| Solid waste | 1.2 | 0.1 | 0.3 | 1.9 | 6.8 |
| Miscellaneous | 1.0 | 0.1 | 0.2 | 12.7 | 5.9 |
| Forest wildfires | 0.4 | 0 | 0.1 | 0.6 | 3.3 |
| Forest managed burning | 0.2 | 0 | <0.1 | 0.2 | 0.6 |
| Agricultural burning | 0.3 | 0 | <0.1 | 0.3 | 1.6 |
| Coal refuse burning | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 |
| Structural fires | <0.1 | 0 | <0.1 | 0 | 0.1 |
| Organic solvents | 0 | 0 | 0 | 7.8 | 0 |
| Oil and gas production and marketing | 0 | 0 | 0 | 3.7 | 0 |
| Total | 26.8 | 34.2 | 22.7 | 33.9 | 113.7 |

recession which curtailed production by a large number of industries. This is particularly evident in the emission reduction from 1974 to 1975, which is shown.

Total emissions of sulfur oxides are estimated to have declined slightly from 1972 through 1975 (Figure 4-1). Monitoring results show that ambient levels in the relatively well-monitored urban areas have declined markedly in recent years (see Section 3), which suggests a significant shift in the use of higher sulfur fuels by urban sources to a growing number of sources in relatively sparsely monitored areas. It has also been estimated [2] that sulfur oxide emissions from electric-power-generating plants increased through at least 1973. These plants contribute some 70 percent of the sulfur oxide emissions in the stationary source category. Clearly, there has been a substantial decrease of sulfur dioxide in the urban areas according to the air quality data.

Trends in oxides of nitrogen emissions (Figure 4-1) have increased primarily because of increased amounts of fuel consumed by electric utilities. To a lesser extent, nitrogen oxide emissions from highway and non-highway mobile sources have also increased. The increase in nitrogen oxide emissions from highway mobile sources is due to growth in vehicle-miles traveled (VMT), as well as the implementation of control measures for CO and hydrocarbons, which have resulted in slight increases in nitrogen oxide emissions above precontrolled levels. For light-duty vehicles nitrogen oxide emission rates per VMT have been reduced since 1972 so that emissions from this category, the mobile source category with the greatest amount of emissions, have been effectively constant from 1972 to 1975.

Total hydrocarbon emission trends (Figure 4-1) have not changed appreciably during the period from 1970 to 1975. While significant reductions in the HC emissions from highway mobile sources have been achieved, these decreases in emissions have been offset by increases in industrial process emissions and

**Table 4-3. NATIONWIDE EMISSION ESTIMATES, 1971**

**($10^6$ tons/yr)**

| Source category | Particulates | $SO_x$ | $NO_x$ | HC | CO |
|---|---|---|---|---|---|
| Transportation | 1.3 | 0.7 | 9.8 | 13.7 | 88.5 |
| Highway | 0.8 | 0.3 | 7.5 | 12.0 | 78.1 |
| Non-highway | 0.5 | 0.4 | 2.3 | 1.7 | 10.4 |
| Stationary fuel combustion | 8.8 | 25.2 | 12.5 | 1.7 | 1.4 |
| Electric utilities | 4.3 | 18.7 | 6.0 | 0.1 | 0.2 |
| Other | 4.5 | 6.5 | 6.5 | 1.6 | 1.2 |
| Industrial processes | 12.8 | 6.2 | 0.6 | 3.5 | 11.2 |
| Chemicals | 0.2 | 0.8 | 0.2 | 1.7 | 4.3 |
| Petroleum refining | 0.1 | 0.7 | 0.3 | 0.8 | 2.3 |
| Metals | 1.6 | 4.0 | 0 | 0.2 | 3.4 |
| Mineral products | 7.9 | 0.6 | 0.1 | 0 | 0 |
| Other | 3.0 | 0.1 | 0 | 0.8 | 1.2 |
| Solid waste | 0.9 | 0.1 | 0.3 | 1.5 | 5.2 |
| Miscellaneous | 1.1 | 0.1 | 0.2 | 12.9 | 7.4 |
| Forest wildfires | 0.6 | 0 | 0.1 | 0.9 | 5.0 |
| Forest managed burning | 0.2 | 0 | <0.1 | 0.2 | 0.6 |
| Agricultural burning | 0.2 | 0 | <0.1 | 0.3 | 1.4 |
| Coal refuse burning | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 |
| Structural fires | <0.1 | 0 | <0.1 | 0 | 0.1 |
| Organic solvents | 0 | 0 | 0 | 7.5 | 0 |
| Oil and gas production and marketing | 0 | 0 | 0 | 3.9 | 0 |
| Total | 24.9 | 32.3 | 23.4 | 33.3 | 113.7 |

evaporative losses from organic solvent use and petroleum product marketing. These increases reflect increased consumption of gasoline and distillate fuels for motor vehicle use and increased solvent use for surface coating, degreasing, and a variety of other uses.

CO emissions have decreased (Figure 4-1) mainly because of the controls applied to highway motor vehicles and decrease in burning of solid wastes. Industrial process emissions have also been reduced by decreases in production and the obsolescence of certain high-polluting industrial processes, such as carbon black manufacture by the channel process.

**Table 4-4. NATIONWIDE EMISSION ESTIMATES, 1972**

($10^6$ tons/yr)

| Source category | Particulates | $SO_x$ | $NO_x$ | HC | CO |
|---|---|---|---|---|---|
| Transportation | 1.3 | 0.7 | 10.4 | 14.0 | 93.5 |
| Highway | 0.9 | 0.3 | 7.9 | 12.2 | 83.2 |
| Non-highway | 0.4 | 0.4 | 2.5 | 1.8 | 10.3 |
| Stationary fuel combustion | 8.1 | 28.9 | 13.1 | 1.7 | 1.4 |
| Electric utilities | 4.0 | 21.3 | 6.5 | 0.1 | 0.2 |
| Other | 4.1 | 7.6 | 6.6 | 1.6 | 1.2 |
| Industrial processes | 12.3 | 6.9 | 0.7 | 3.8 | 11.2 |
| Chemicals | 0.2 | 0.9 | 0.3 | 1.8 | 4.1 |
| Petroleum refining | 0.1 | 0.8 | 0.3 | 1.0 | 2.3 |
| Metals | 1.7 | 4.5 | 0 | 0.2 | 3.6 |
| Mineral products | 7.4 | 0.6 | 0.1 | 0 | 0 |
| Other | 2.9 | 0.1 | 0 | 0.8 | 1.2 |
| Solid waste | 0.8 | 0.1 | 0.2 | 1.2 | 4.4 |
| Miscellaneous | 0.9 | 0.1 | 0.2 | 13.4 | 5.3 |
| Forest wildfires | 0.4 | 0 | 0.1 | 0.6 | 3.5 |
| Forest managed burning | 0.2 | 0 | < 0.1 | 0.2 | 0.5 |
| Agricultural burning | 0.2 | 0 | < 0.1 | 0.2 | 0.9 |
| Coal refuse burning | 0.1 | 0.1 | 0.1 | < 0.1 | 0.3 |
| Structural fires | < 0.1 | 0 | < 0.1 | 0 | 0.1 |
| Organic solvents | 0 | 0 | 0 | 8.4 | 0 |
| Oil and gas production and marketing | 0 | 0 | 0 | 4.0 | 0 |
| Total | 23.4 | 36.7 | 24.6 | 34.1 | 115.8 |

**Table 4-5. NATIONWIDE EMISSION ESTIMATES, 1973**

**($10^6$ tons/yr)**

| Source category | Particulates | $SO_x$ | $NO_x$ | HC | CO |
|---|---|---|---|---|---|
| Transportation | 1.3 | 0.7 | 10.9 | 13.7 | 90.3 |
| Highway | 0.9 | 0.4 | 8.1 | 11.8 | 80.0 |
| Non-highway | 0.4 | 0.3 | 2.8 | 1.9 | 10.3 |
| Stationary fuel combustion | 7.5 | 28.0 | 13.7 | 1.7 | 1.4 |
| Electric utilities | 3.7 | 22.0 | 7.0 | 0.1 | 0.3 |
| Other | 3.8 | 6.0 | 6.7 | 1.6 | 1.1 |
| Industrial processes | 11.7 | 6.7 | 0.7 | 3.7 | 11.5 |
| Chemicals | 0.2 | 0.9 | 0.3 | 1.8 | 4.4 |
| Petroleum refining | 0.1 | 0.9 | 0.3 | 0.9 | 2.4 |
| Metals | 1.6 | 4.1 | 0 | 0.2 | 3.5 |
| Mineral products | 7.0 | 0.7 | 0.1 | 0 | 0 |
| Other | 2.8 | 0.1 | 0 | 0.8 | 1.2 |
| Solid waste | 0.7 | 0.1 | 0.2 | 1.1 | 4.0 |
| Miscellaneous | 0.7 | 0.1 | 0.2 | 13.8 | 4.3 |
| Forest wildfires | 0.4 | 0 | 0.1 | 0.5 | 2.7 |
| Forest managed burning | 0.1 | 0 | 0 | 0.2 | 0.5 |
| Agricultural burning | 0.1 | 0 | 0 | 0.1 | 0.7 |
| Coal refuse burning | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 |
| Structural fires | <0.1 | 0 | 0 | 0 | 0.1 |
| Organic solvents | 0 | 0 | 0 | 8.7 | 0 |
| Oil and gas production and marketing | 0 | 0 | 0 | 4.2 | 0 |
| Total | 21.9 | 35.6 | 25.7 | 34.0 | 111.5 |

**Table 4-6. NATIONWIDE EMISSION ESTIMATES, 1974**

($10^6$ tons/yr)

| Source category | Particulates | $SO_x$ | $NO_x$ | HC | CO |
|---|---|---|---|---|---|
| Transportation | 1.3 | 0.8 | 10.6 | 12.5 | 82.1 |
| Highway | 0.9 | 0.4 | 8.1 | 10.9 | 72.8 |
| Non-highway | 0.4 | 0.4 | 2.5 | 1.6 | 9.3 |
| Stationary fuel combustion | 7.0 | 26.8 | 13.3 | 1.7 | 1.4 |
| Electric utilities | 3.4 | 21.1 | 6.9 | 0.1 | 0.3 |
| Other | 3.6 | 5.7 | 6.4 | 1.6 | 1.1 |
| Industrial processes | 10.6 | 6.3 | 0.7 | 3.7 | 11.0 |
| Chemicals | 0.2 | 1.0 | 0.3 | 1.8 | 4.1 |
| Petroleum refining | 0.1 | 0.9 | 0.3 | 0.9 | 2.5 |
| Metals | 1.5 | 3.7 | 0 | 0.2 | 3.3 |
| Mineral products | 6.3 | 0.7 | 0.1 | 0 | 0 |
| Other | 2.5 | <0.1 | 0 | 0.8 | 1.1 |
| Solid waste | 0.6 | 0.1 | 0.2 | 1.0 | 3.5 |
| Miscellaneous | 0.8 | 0.1 | 0.2 | 14.0 | 5.3 |
| Forest wildfires | 0.5 | 0 | 0.1 | 0.6 | 3.8 |
| Forest managed burning | 0.1 | 0 | <0.1 | 0.2 | 0.5 |
| Agricultural burning | 0.1 | 0 | <0.1 | 0.1 | 0.6 |
| Coal refuse burning | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 |
| Structural fires | <0.1 | 0 | <0.1 | 0 | 0.1 |
| Organic solvents | 0 | 0 | 0 | 8.9 | 0 |
| Oil and gas production and marketing | 0 | 0 | 0 | 4.1 | 0 |
| Total | 20.3 | 34.1 | 25.0 | 32.9 | 103.3 |

**Table 4-7. NATIONWIDE EMISSION ESTIMATES, 1975 (PRELIMINARY)**

($10^6$ tons/yr)

| Source category | Particulates | $SO_x$ | $NO_x$ | HC | CO |
|---|---|---|---|---|---|
| Transportation | 1.3 | 0.8 | 10.7 | 11.7 | 77.4 |
| Highway | 0.9 | 0.4 | 8.2 | 10.0 | 67.8 |
| Non-highway | 0.4 | 0.4 | 2.5 | 1.7 | 9.6 |
| Stationary fuel combustion | 6.6 | 26.3 | 12.4 | 1.4 | 1.2 |
| Electric utilities | 3.5 | 21.0 | 6.8 | 0.1 | 0.3 |
| Other | 3.1 | 5.3 | 5.6 | 1.3 | 0.9 |
| Industrial processes | 8.7 | 5.7 | 0.7 | 3.5 | 9.4 |
| Chemicals | 0.2 | 1.0 | 0.3 | 1.6 | 3.3 |
| Petroleum refining | 0.1 | 0.9 | 0.3 | 0.9 | 2.2 |
| Metals | 1.3 | 3.2 | 0 | 0.2 | 2.8 |
| Mineral products | 4.5 | 0.6 | 0.1 | 0 | 0 |
| Other | 2.6 | <0.1 | < 0.1 | 0.8 | 1.1 |
| Solid waste | 0.6 | <0.1 | 0.2 | 0.9 | 3.3 |
| Miscellaneous | 0.8 | 0.1 | 0.2 | 13.4 | 4.9 |
| Forest wildfires | 0.4 | 0 | 0.1 | 0.6 | 3.3 |
| Forest managed burning | 0.1 | 0 | <0.1 | 0.2 | 0.5 |
| Agricultural burning | 0.1 | 0 | <0.1 | 0.1 | 0.6 |
| Coal refuse burning | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 |
| Structural fires | 0.1 | 0 | <0.1 | <0.1 | 0.1 |
| Organic solvents | 0 | 0 | 0 | 8.3 | 0 |
| Oil and gas production and marketing | 0 | 0 | 0 | 4.2 | 0 |
| Total | 18.0 | 32.9 | 24.2 | 30.9 | 96.2 |

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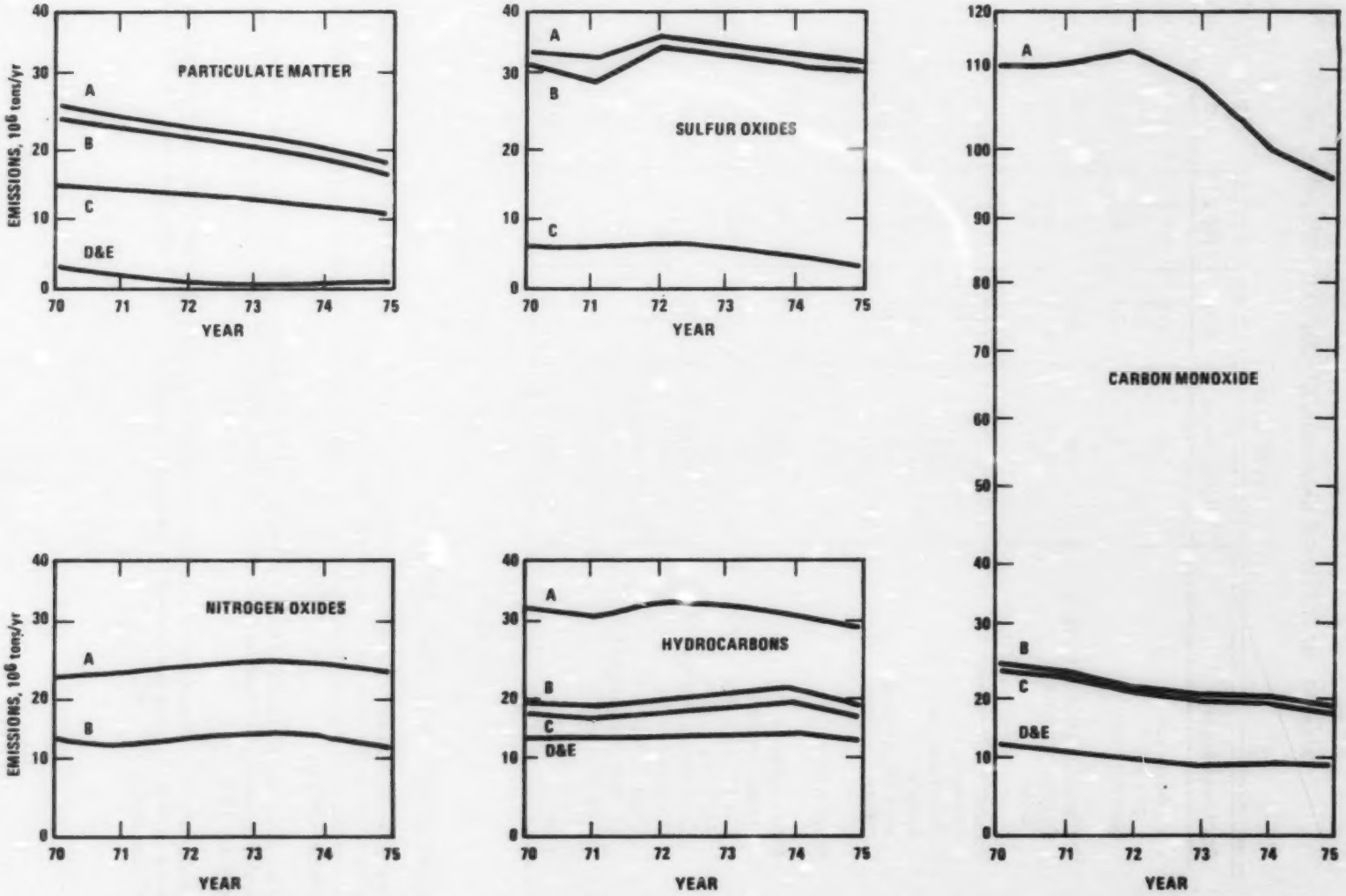


*Figure 4.1. Calculated total emmissions of criteria pollutants by source category, 1970 through 1975 (A: Transportation, B: Stationary Source Fuel Combustion, C: Industrial Processes, D: Solid Waste, E: Miscellaneous).*